THE PRACTICAL PAPER MAKER

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PRACTICAL PAPERMAKER:

A Complete Guide

TO THE

MANUFACTURE OF PAPER.

By JAMES DUNBAR.

Third Edition, Revised and Enlarged.

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PREFACE TO THIRD EDITION.

The object of the Author is to present the reader with a minute detail of the art of Papermaking in its most modern form, and sufficiently broad to lay a foundation of acquiring habits of skill and economy, with precise and minute particulars of every stage of the manufacture of paper.

The art of Papermaking does not confine the student to the production only of paper, but it carries him into the vegetable and mineral kingdoms. In fact, it extends its dominion over a great portion of the economy of nature, and is seen ministering in every direction to the development of knowledge and education. Although modern Papermaking is necessarily becoming every day more and more important, yet perhaps its value as an essential branch of education has not been duly estimated. Nor is it surprising that Papermaking, from the rapidity with which it has arisen and attained a first rank amongst the manufactures, is daily adding to its power of imparting knowledge and increasing practical skill. It is only from adverting to these considerations that I can explain how the practice of an art so eminently useful has not been more generally taught. And, indeed, not many years ago it was not considered possible that classes could be arranged for this purpose, unless at such an expense

as to have precluded the greater number of students from taking advantage of them.

I may also observe that the student who is engaged in a series of experiments connected with the manufacture of paper, properly conducted, is not only acquiring those practical habits which will stand in good stead in after life, and will enable him to apply his knowledge to useful purposes, but is placed in a situation most favourable to render it at once accurate, permanent, and effective. The interest he necessarily feels in the success of his undertakings quickens his attention to everything that may influence the result, and forces him to an intimate acquaintance with the nature of every material with which he operates. Although no written directions can supply the place of practical habits, or give that dexterity, readiness, and resource which are to be acquired only by being conversant with the operations of a paper manufactory, yet much may be done to facilitate the student's progress by minute and definite directions as may enable him to acquire a knowledge of the practical relations of Papermaking, and the mode of procedure with the different kinds of material with which he may come in contact.

It is with the hope of being useful in this respect that I am prompted to add my item, however unworthy it may be.

JAMES DUNBAR.

KINLEITH PAPER MILLS,
CURRIE.

INDEX.

	PAGE
Alum	91
Aluminous Cakes	92
Aniline Colours	86
Beating Engine	14, 41
Beating or Refining Department	35
Bleaching Powder	93
Bleach Test	84
Blotting Paper	100
Caustic Soda, Boiling with	9
Chemicals necessary for Boiling	29
Chemistry, Scraps of	91
Cochineal	85
Colouring Matter—	
Antichlorine	83
Berlin Blue	82
Catechu	82
Pernambuco Dye-wood	83
Draining and Pressing	11
Esparto	17
Do. Bleaching	32
Do. Boilers	28
Do. Boiling	26
Do. Willow	25
Half-Stuff, Gas Bleaching	12
Do. Potching	13
Do. Reducing to	31
Half-Stuff Machine	33
Lime and Soda Ash, Preparation of	8
Mechanical Department	56
Steam Power	58
Steam Engine	59

	PAGE
Papermaking Machines—	41
Belting	53
Cylinders	48
Dandy Rolls	52
Drying Machine	55
Felts	51
Glazing Rolls	49
Paper Cutting	54
Paper Glazing	56
Press Rolls	47
Sand Traps	43
Sizing and Drying	54
Strainers	43
Stuff Chests	41
Stuff Pump	42
Wire and Connections	44
Wire-cloth	50
Plate Glazing	56
Rags—	
Boiling	6
Classification of	4
Selection and Assortment of	1
Raw Material	16
Receipts—	
Coloured Papers	67
Coloured Esparto Papers	80
High-Class Papers	63
Receiving Apparatus	30
Ropes, Boiling of	8
Size, Engine—Preparation of	85
Do. Soap	86
Do. Turpentine	86
Soda, Its Causticity	94
Test Papers, Coloured	97
Ultramarine	89
Washing and Breaking	10
Wood Pulp	62

THE PRACTICAL PAPERMAKER.

Selection and Assortment of Rags.

The selection and assortment of the raw material form a very important branch of the Paper Trade.

Rags are brought to the mill in an unsorted condition, and are called Mixed Rags.

The system of assorting and classifying rags in common use in this country, and the distinguishing mark given to each sort, cause considerable confusion to the tyro in the trade, and rather retard than facilitate the work of this department, which ought to be conducted on principles readily comprehended and easily impressed upon the memory.

The superiority of the system in vogue on the Continent—its greater simplicity, and therefore efficacy, and the great saving of time (a most important item in the economical working of a factory) effected by it—will be shown in the following description.

The Rag department in Continental mills consists of a two-storey building, on the ground floor of which all the cutting and sorting are done. The upper storey is fitted up with twenty stalls or compartments, numbered from 1 to 20. The rags, having been cut and overhauled, are hoisted to the second flat, and there deposited, under the superintendence of the foreman, according to their respective

qualities in the numbered compartments, and thence taken to the willows in quantities of the various sorts, to make up the desired stuffs ordered by the manager.

The rags are known by number as follows :—

No. 1 Rags—White linen without seams, fine clean.
,, 2 ,, White linen with seams, fine clean.
,, 3 ,, White linen with seams, second quality.
,, 4 ,, White linen with seams, third quality.

The three last-mentioned qualities are easily distinguished, for as the quality deteriorates the rags become thicker, and, the thicker the rags, the greater the quantity of sheive they contain.

No. 5 Rags—Blue linen without seams, first quality.
,, 6 ,, Blue linen with seams, second quality.
,, 7 ,, Blue linen with seams, third quality.
,, 8 ,, Good linen, seconds.
,, 9 ,, Coarse linen, seconds.
,, 10 ,, White cotton, fine, first quality.
,, 11 ,, White cotton, second quality.
,, 12 ,, Coloured cotton, third quality.
,, 13 ,, Sailcloth without seams, first quality.
,, 14 ,, Sailcloth with seams, second quality.
,, 15 ,, Fine hemp bagging, good clean.
,, 16 ,, Good hemp bagging.
,, 17 ,, Hemp rope, fine clean.
,, 18 ,, Hemp rope, good clean.
,, 19 ,, Hemp rope, free from tar, third quality.
,, 20 ,, Broke from all the above except the rope.

The simplicity and efficiency of sorting the different rags by this method of numbers are evident; the workpeople having only to know that the higher the number is, the coarser is the quality of the rags. No. 1 is the equivalent for S.P.F.F.F.

Blending or arranging the rags for the different stuffs suitable for the various qualities of paper to be made is a work of considerable difficulty, and requires the greatest care. For example, a paper of a

certain quality is desired: the difficulty is to blend that proportion of cotton with linen rags which will produce a paper, tough, strong, well-sized, and possessing those elastic qualities which will permit it to be folded into any shape without showing signs of cracking, as is especially necessary in book papers.

The most convenient, and at the same time most efficacious, mode of procedure is to form the various rags into stuffs, such as No. 1 Stuff, No. 3 Stuff, No. 4 Stuff, No. 5 Stuff, and stuff specially prepared for tissue and copying papers, composed as follows:—

No. 1 STUFF.

No. 2 Rags, . . .	1200 lb.
,, 5 ,, . . .	2800 ,,
	4000 lb.

No. 3 STUFF.

No. 4 Rags, . . .	400 lb.
,, 6 ,, . . .	1200 ,,
,, 8 ,, . . .	2400 ,,
	4000 lb.

The above No. 1 and No. 3 Stuffs are for specially strong papers.

No. 4 STUFF.

No. 7 Rags, . . .	1600 lb.
,, 9 ,, . . .	2800 ,,
,, 20 Broke, . . .	400 ,,
	4800 lb.

If the broke accumulates, a larger proportion can be used in making coloured papers, otherwise the above quantity is sufficient. Rags Nos. 10, 11, and 12 are specially reserved for blending, for thick papers, or for printings of a high class. Nos. 13, 14, 15 and 16 supply the place of any of the num-

bers for which they are suited. No. 1 can be drawn upon in the event of a special paper being desired.

No. 5 STUFF.

No. 6 Rags, . . .	1600 lb.
,, 8 ,, . . .	2400 ,,
	4000 lb.

This No. 5 Stuff is principally used for mixing with the Rope Stuff for tissue and copying papers, in proportions which will be given in the receipts for thin papers.

ROPE STUFF.

No. 17 Ropes, . . .	2600 lb.
,, 18 ,, . . .	1200 ,,
,, 19 ,, . . .	200 ,,
	4000 lb.

It may be mentioned that the qualities of paper on the Continent are known by numbers, No. 1 being the highest quality of writings and printings. The different qualities of paper that can be made from the various stuffs are as follows :—

From No. 1 Stuff, extra superfine, or No. 1 papers.
,, 3 ,, superfine and fine papers.
,, 4 ,, fines, fourths, and coloured papers.
,, 5 ,, thin papers ; also used for mixing with the rope stuff, for cigarette, copying, and tissue papers.

Classification of Home and Foreign Rags

According to the Method generally adopted in this Country, with their Distinguishing Names.

Superfines, S.P.F.F.F., S.P.F.F., S.P.F., Dark Fines, Grey or Green Linen, New Pieces, Sail-cloth, F.F., L.F.X., C.L.F.X., C.C.L.F.X., Fines,

Seconds, Thirds, Cords both dark and light, Outshots, Prints, and the various qualities of Hemp and Jute Bagging.

Superfines	consist of	superfine new white shirt cuttings.
S.P.F.F.F.	,,	extra superfine white linen, first quality.
S.P.F.F.	,,	superfine white linen, second quality.
S.P.F.	,,	fine white linen, third quality.
Dark Fines	,,	fine white cotton rags, well adapted for blotting paper of a good quality.
Green Linen	,,	fine unbleached linen cuttings.
New Pieces	,,	fine bleached linen cuttings.
Sailcloth	,,	canvas (worn) and new cuttings.
F.F.	,,	coarse Russian linen rags, first quality.
L.F.X.	,,	coarse Russian linen rags, second quality.
C.L.F.X.	,,	coarse Russian linen rags, third quality.
C.C.L.F.X.	,,	coarse Russian linen rags, fourth quality.

The last four sorts of rags are casily distinguished, as there is considcrable difference in the quality and appearance, the rags being thicker and sheivier as the quality deteriorates.

Fines	consist of	fine white cottons.
Seconds	,,	soiled white cottons.
Thirds	,,	extra dirty cotton liniugs.
Light and Dark Cords	consist of	light and dark cottons (thick).
Outshots	consist of	good, strong, and sound rags.
Prints	,,	cotton of various grades.

Home linen rags are often mixed with jute and cotton. When jute is present in linen, the colour is not so good when manufactured. The simplest method of discovering the presence of jute in linen is to wash a sample, and treat with diluted chlorine, when the jute will assume a red colour, and the linen bleach white. With cotton in linen, destroy the cotton with sulphuric acid, and only the linen will remain.

Methods of Rag Boiling.

Description of Boilers—Steam Pressure—Quantities of Lime, Soda Ash, Caustic Soda, and Time of Boiling.

Boiling the raw material is the most important part in the manufacture of paper. Any neglect in this department cannot be remedied after the material has left the boilers; hence the necessity for the exercise of the greatest care and most unremitting attention at all times.

The foreman ought to have a thorough knowledge of the nature of the raw material. It is not merely sufficient to know that the material is either cotton or linen, but it is absolutely necessary to know how to bring that material to the highest state of perfection without injury to its texture, and with a proper regard to the cost. Much, of course, depends upon the facilities for boiling, and the quality of the water, whether soft or hard. These things must be taken into consideration, and arrangements made accordingly.

All rags, even the finest cotton, contain sheive, which nothing but judicious boiling will remove. Badly boiled stuff also consumes too much chlorine, and makes a poorer-looking paper than when properly treated in this department. Great waste of chemicals ensues when proper care is not exercised; and more especially is this the case with esparto, one lot boiling with two or three pounds less caustic soda to the cwt. than others. Again, there is considerable difference in boiling summer and winter esparto. The summer requires more boiling than the winter, and turns out better,—a fact attributable to the smaller amount of moisture contained in the former.

Those in charge here should be thoroughly ac-

quainted with these facts, and should see that everything is in its proper place and in proper condition, and that there is no leakage at the boiler doors, steam joints, or valves. When everything is in good order, and strict attention paid to cleanliness, this department wears an aspect of serenity and comfort, never seen but where method is followed and care exercised.

Continental System of Boiling.

Rags on the Continent are boiled with lime and soda ash in a very satisfactory and economical manner, as follows :—

No. 1 STUFF.

Lime . .	216 lb.	for 4000 lb. rags,
Soda Ash*	114 ,,	

boiled for 12 hours with 30 lb. steam pressure in a boiler revolving horizontally.

Nos. 3 and 5 STUFFS.

Lime . .	324 lb.	for 4000 lb. rags,
Soda Ash*	152 ,,	

boiled for 12 hours with 30 lb. steam pressure in a boiler revolving horizontally.

No. 4 STUFF.

Lime . .	378 lb.	for 4800 lb. rags,
Soda Ash*	190 ,,	

boiled for 12 hours with 30 lb. steam pressure in a boiler revolving horizontally.

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* 48 per cent.

Boiling of Ropes for Tissue, Copying, and Cigarette Papers.

Lime . .	648 lb.	for 4000 lb. rope,
Soda Ash*	456 ,,	

boiled for 24 hours with 30 lb. steam pressure in a boiler revolving horizontally.

Preparation of Lime and Soda Ash.

Milk of lime is prepared and strained in the following manner:—Construct a large wooden box 15 ft. long, 5 ft. wide, and 4 ft. deep, divided into three compartments, with false bottoms, perforated with $\frac{1}{2}$-inch holes to retain small stones and sand. In the first compartment the lime is slaked and reduced to a powder; it is then put over into the second compartment, and converted into milk of lime. In the partition between the second and third compartments there is a moveable sluice, allowing the milk to flow into the third division in quantities regulated by the man in charge. In the third compartment there is fitted a revolving drum, exactly the same as the ordinary drum washer of a half-stuff engine. The milk of lime flowing through the sluice is strained by the revolving drum, on the same principle as that by which the water is lifted from a breaking engine, and is discharged through a pipe direct into the rag boilers. If the lime requires extra straining, a fine wire strainer can be put over the mouth of the pipe leading to the boiler, and the lime passed through it. The several compartments are furnished with large waste pipes, which with a liberal supply of water carry off all impurities and what the drum has rejected. This system is a satisfactory and cleanly one.

Soda Ash.

The preparation of soda ash is conducted in very different ways. Some introduce it into the newly-slaked lime while the excessive heat lasts which is generated by the slaking; others, again, put the soda ash direct into the boiler. The latter should never be done on any pretext whatever. Nothing should be put into the boiler without straining. The best method is to dissolve the soda ash separately, and strain through a fine wire strainer into the boiler.

By adopting the above principles, the boiling department is kept orderly and clean,—a most important object in the manufacture of paper, than which no manufactured goods are more liable to damage from carelessness and dirty habits.

Boiling with Caustic Soda.

Boiling with lime alone is a much better and safer method than any other for fine-textured materials. The rags certainly turn out better, and it is therefore more economical.

The quantities of caustic soda for the cwt. of the various qualities of rags are as follows :—

S.P.F.F.F. is boiled with lime alone, then washed in the boiler, and again boiled with 2 per cent. of soda ash.

S.P.F.F.	is	boiled with	12	lb.	of caustic soda*	per cwt.
S.P.F.	,,	,,	14	,,	,,	,,
Fines	,,	,,	7	,,	,,	,,
Seconds	..	,,	6	,,	,,	,,
L.F.X.	,,	,,	20	,,	,,	,,
C.L.F.X.	,,	,,	27	,,	,,	,,
C.C.L.F.X.		,,	30	,,	,,	,,
F.F.	,,	,,	15	,,	,,	,,

all boiled with steam at a pressure of 20 to 25 lb. for

* 70 per cent.

10 hours in stationary boilers without vomit, and also in boilers revolving horizontally.

Washing and Breaking.

Considerable experience and great care are required in reducing rags to half-stuff. If more attention were given to the first stages in the manufacture of paper, the subsequent duties of those in charge would be less burdensome, and the particular class of paper desired be produced with comparatively little trouble and a very small percentage of retree.

The rags should be gradually introduced into an engine, previously half filled with water. When the desired quantity (which should never be too thick and difficult to turn) is filled in, go on washing, and let down the roll just sufficient to open up the rags and let the dirt escape, at the same time using the stirring stick right above the sand-trap, round the sides, and at the back fall of the engine. This prevents "lodgers," or pieces of rag not reduced to half-stuff, hanging about, which, if allowed to escape, would cause knots and grey specks in the paper. The rags must on no account be cut up or forced, but drawn out into fibre without having the smallest particle of rag unreduced to half-stuff; and this can only be accomplished by a liberal use of the stirring stick and the valve hook at the back fall of the engine. When the stuff is in condition for emptying into the drainers, the valve should be drawn with care, and deposited on the floor until the engine is empty.

The man in charge of this department should be made to understand that the quality of the paper depends greatly upon his knowledge of his business and the cleanliness of his surroundings.

Before replacing, the valve must be carefully washed, as the hole on the top is always full of dirt and sand, which, when the valve is carelessly drawn, escapes with the stuff. Next lift the sand-trap plate, and remove carefully all impurities, replace the plate, and fill up again. Much depends on the treatment of the stuff in this department whether the paper will possess the requisite strength, for if too quickly reduced to half-stuff the material is rendered weaker, and the washing is insufficiently done; while, if the stuff is properly drawn out into fibre, and timed, its texture is not injured,—it is better washed, and produces a stronger paper.

Draining and Pressing.

When the stuff is emptied from the washing-engine into the drainers, it immediately commences to drain, and, when properly drained for removal, is subjected to pressure.

The best method of pressing or extracting the water from the stuff is by the extractor or centrifugal drainer, which dries the stuff sufficiently either for gasing or conveying to the potcher, as the case may be. This department ought to be kept scrupulously clean, and should be supplied with a box to contain any stuff that may accidentally drop on the floor and get dirty. All boxes or waggons connected with it ought to be periodically washed, and kept perfectly clean. The floor ought to be washed once a day, and everything kept in its proper place. All this is necessary, not only to ensure perfectly clean stuff, but also from a sanitary point of view, as the workman will find that, where a system of cleanliness and order is adopted, the department wears a healthier and more cheerful aspect than where dirt and disorder are predominant.

Gas-Bleaching Half-Stuff.

Gas-bleaching half-stuff is seldom resorted to in this country, but is still carried on in Russia, and is almost indispensable for bleaching the coarse linen rags so plentiful in that country.

Half-stuff, to be satisfactorily gas-bleached, must contain a sufficient amount of moisture, otherwise the outside only will be bleached, and that even an indifferent colour. On the other hand, if the stuff is too wet, the same results will follow. In order to ensure, therefore, a good uniform colour, great care must be taken to see that the stuff contains the proper amount of moisture, and no more. A generally effective method of testing the state of the stuff is to squeeze it between the hands, when, if the pressure causes no escape of water, yet still retains a damp appearance, it is in a proper condition for gas-bleaching.

The method of bleaching is as follows:—Put 1600 lb. of half-stuff, in the condition mentioned above, loosely into a stone chamber, and seal it in such a manner that it will be perfectly air-tight. Into the lead retort, connected with this chamber by leaden pipes, pour 3 pails of water and 66 lb. of common salt; stir thoroughly, add 65 lb. of manganese; stir again, and close the retort. Next charge a leaden vessel with 119 lb. of vitriol, and let the vitriol drop into the retort containing the water, salt, and manganese, through a bell-mouthed bent syphon, which admits the vitriol and at the same time prevents the escape of gas. (Three hours must be allowed for the vitriol to drop into the retort.) Then heat the retort with steam for seven hours, and allow two hours for the gas to escape up the mill chimney. For fine stuff, such as willowed rope, one hour extra must be allowed for the escape of the gas.

The quantities of manganese, salt, and vitriol used for the different stuffs previously mentioned are—

No. 1 STUFF.

FOR 1600 LB. HALF-STUFF.

50 lb. manganese; 50 lb. salt; 80 lb. vitriol.

No. 3 STUFF.

FOR 1600 LB. HALF-STUFF.

60 lb. manganese; 60 lb. salt; 100 lb. vitriol.

No. 4 STUFF.

FOR 1600 LB. HALF-STUFF.

65 lb. manganese; 66 lb. salt; 119 lb. vitriol.

ROPES FOR COPYING PAPER, &c.

FOR 1400 LB. HALF-STUFF.

81 lb. manganese; 91 lb. salt; 124 lb. vitriol.

Potching Half-Stuff previously Gas-Bleached.

No. 1 STUFF.

FOR 600 LB.

15 gallons chlorine at 4½ degrees.

No. 3 STUFF.

FOR 600 LB.

20 gallons chlorine at 4½ degrees.

No. 4 STUFF.

FOR 500 LB.

12 gallons chlorine at 5 degrees.

Potching Half-Stuff.

The quantities of half-stuff filled into the potching engine should at all times be as uniform as possible; for if the quantity of stuff is changed and the bleach

not varied in proportion, an irregularly-bleached stuff will be produced. When the engine is filled, wash for some time with a finer wire than is used on the breaker. When thoroughly washed, raise the washer and introduce the bleaching liquor in sufficient quantity for the material to be bleached, care being taken not to exceed the amount ordered by the manager, not only as a matter of economy in chlorine, but also on account of the injury the stuff would suffer.

In the case of vitriol being used, a small leaden vessel must be placed in such a position that the vitriol will drop into the engine at the rate of one pound of vitriol in twenty minutes. The vitriol should be diluted before using, taking care, in order to prevent excessive effervescence and a disagreeable smell, that the vitriol be added to the water, and not the water to the vitriol. When the bleaching process is finished, the stuff is emptied into stone chests, each capable of containing two engines of material. These chests are fitted with perforated zinc drainers—one in the extreme bottom, and another running up the back of the chest, connected with the one in the bottom. The stuff is generally allowed to remain in the chests as long as time will permit, but, to ensure a regularly-coloured stuff, it is better to allow a fixed time.

Beating Engine Department.

This is another very important department in the paper mill, and should be roomy, and kept in good order, and perfectly clean. The man in charge should be a thoroughly-experienced workman, in whom every confidence can be placed, who will not add to or take from any order given by the manager without previous consultation.

The journals of the roll shaft should be frequently wiped, and no stuff should be allowed to escape at the ends of the roll or from below the edge of the roll cover, as the continual vibration of the cover rubs the stuff, and forms it into small black specks, which escape with it and show in the paper. In order to ensure a uniform colour, everything must be put into the engine in proper order at the right time, and in the exact quantities ordered; nor should anything be put into the engine without being previously strained, no matter how clean it may be, as, by this system, straining, when actually required, is never neglected. Colouring matter should be measured or weighed, as the case may be, with the greatest exactness. Size and alum should also be carefully measured.

Whenever the engine is filled, commence washing, and continue for some time. In making animal-sized papers, a quantity of antichlorine should be introduced immediately the washing is finished, to neutralize the chlorine; but with engine-sized papers the loading should be first introduced, then the size, then the alum, and lastly the colouring matter. The water bags should never be shaken or squeezed, and, when they show any signs of being dirty, should be at once changed. The preparation of the stuff must be timed according to the thickness of the paper wanted, and in proportion to the uniformity of time used in preparing a lot to be made at a given weight will the regularity in quality and weight run at the machine.

Much depends on the workmen in this department whether the pulp is of the desired quality or not. A comparatively weak material can be made into a reasonably strong paper, if properly treated in the beating engine; but if the stuff is carelessly handled, such as by sending out stuff for laid paper too fast

and long, or too soft and carrying too much water, the weight will vary, and the paper crush at the couchers and stick at the press rolls, causing all sorts of trouble and confusion to the machineman, and a considerable amount of waste.

Receiving the Raw Material.

Much depends upon the condition of the raw material when received at the mill, whether it will turn out satisfactory as a papermaking material and remunerative to the paper manufacturer, or otherwise. This applies principally to Esparto, in consequence of its being delivered loose, and in ordinary baling without wrappers of any kind. Hence, when it is loaded in dirty ship-holds, or when it forms only a part cargo, it is sometimes polluted with ores of different kinds: being cut open to facilitate loading, or loaded in dirty waggons (which at times does occur), it is rendered very liable to take up a considerable amount of dirt, which is difficult to get rid of, and which might, by ordinary care, be almost entirely avoided.

The quantity of loose grass which may be looked for in all consignments is generally 10 per cent.; but this quantity is very often exceeded, and is a matter worthy the consideration of the papermaker. As it cannot be well kept together, it consequently gets dirty, and is rendered thereby an agent for polluting the clean article by admixture therewith. Hence the absolute necessity of not only the papermaker exercising the utmost cleanliness, but those also engaged in baling, shipping, discharging, and forwarding the esparto to its destination ought to be extremely careful.

Much damage is also done to esparto by allowing it

to get damaged by wet, either when in bale, or baling when in a wet state, or by salt water, or in transit by rail. It consequently heats, and is not only rendered dangerous, but gets mouldy, turns black, and begins to rot, which, if not remedied, will render it perfectly useless as a papermaking material. Hence every care ought to be taken to avoid these evils, which are not only a loss to the paper manufacturer, but also a cause of dispute between him and the esparto merchant; while, at the same time, neither of them can avoid it, it being entirely beyond their control, and in the hands of others who are not perfectly aware of the results. The goods ought to be delivered at the mill in as perfect a state as possible, which is necessary in these days of unremunerative prices for finished paper, which leave the manufacturer a very meagre margin.

Storage of Esparto.

Esparto being a material so easily damaged by damp, it ought not, upon any pretext whatever, to be stored in the open air, as by doing so it is liable to get wet, which often saturates it, thereby exposing it to the danger of heating, which brings out the resinous or gummy matter—this substance retaining all the dust and dirt flying about, which adheres to it with the utmost persistency, and is with the greatest difficulty separated from it, rendering it a source of trouble and loss to the paper manufacturer in giving him a greater percentage of waste than otherwise might be if the esparto were sufficiently looked after.

Esparto ought to be properly stored and protected under a good roof and upon a dry floor. If the storehouse has no wooden floor, at least old wood ought to be put under it in such a manner that it

will not come in contact with the damp ground, where it is liable to take up dirt and moisture, which are both deleterious to the raw material, by rendering it both dangerous and unfit for papermaking purposes.

The storeroom should also be provided with sliding doors, which ought to be kept shut when not in use: this will have a tendency to keep the material clean, and institute at the beginning of the process of papermaking a systematic cleanliness and care, which cannot be too carefully attended to, as of course the paper manufacturer pays as much for the material which produces retree as for that which produces perfect paper. It is also a matter of self-interest to those in charge of the various stages the raw material passes through, as, where there are prosperous employers, there also will be prosperous workmen and a well-conducted manufactory.

Spanish Esparto.

Spanish esparto is considered the most suitable for papermaking purposes, being stronger and cleaner, and comes to a better colour than the other varieties, of which there are several.

They all evidently belong to one family, from their close resemblance to each other in many respects. But whether it is the effect of climate or soil which renders the Spanish esparto the most valuable article as a papermaking material, it is difficult to determine; nevertheless it is well known in the trade to be such.

Spanish esparto is generally of a fine yellow or amber colour, and has a hard and wiry feel, the root being of a deeper amber than the esparto itself, and generally smaller and straighter than the other varieties. It seldom is long and rank, but gene-

rally short and firm, varying in length from 10 to 12 inches, and of a generally more matured appearance. In fact, there is a look of superiority about it which denotes it at once as the best article, which it shows itself to be in the process of manufacture and in producing the best paper.

African Esparto.

African esparto consists chiefly of the following varieties:—Oran, Tripoli, Sfax, Gabes, and Susa. Hence we will describe them in order as to quality and adaptability for papermaking purposes.

Oran Esparto.—First in order comes the Oran or Algerian esparto, which is considered the best of the African varieties. In general quality it has a closer resemblance to the Spanish esparto than any of the others, in consequence of it being of about the same length of growth, and sometimes of that amber colour. But the roots of the Oran are large and bunchy, and of a dark-red colour, verging on black. It is also, as a rule, softer to the feel, and of a less matured appearance, being light-green in colour and of a spongy nature.

Tripoli Esparto is a strong-growing plant, judging from its appearance upon being received in this country, it being sometimes as long as 2½ or 3 feet, and proportionately thick and bulky. It is still softer to the feel than the Oran esparto, and of a deeper green colour, having large unshapely roots, and a fair proportion of a nettle-like weed, which, when allowed to mix with the esparto, shows up in clear, glassy, transparent specks in the finished paper, being also more difficult to boil; and, if not sufficiently boiled, is difficult to work in the subsequent treatment—producing a paper lacking that

finished character desired by the maker and consumer. At best it does not produce a strong paper when used alone, but upon being mixed with Oran esparto the results are more satisfactory.

Sfax and Gabes Esparto resemble the Oran more than the Tripoli, not being so rank in growth, but inferior in point of strength when compared with Oran esparto, its green spongy nature indicating moisture in excess.

Susa Esparto, if of a good quality, is considered equal to Oran, but it is not so satisfactory in percentage of turn-out. However, it is a variety which is comparatively clean, and this enhances its value.

Winter and Summer Esparto.

Winter and Summer esparto of all varieties have quite a different appearance, and, as a matter of economy, require different treatment in the boiling department.

Summer esparto of all kinds has a more matured appearance than the winter, being more wiry and tough, and, as a rule, more difficult to boil; but it produces the best fibre, and turns out the greater percentage of paper. On the other hand, winter esparto of all kinds has a green, unripe appearance, evidently containing more moisture; in fact, it has always a look of inferiority about it.

Bringing forward Esparto.

It is necessary to exercise great care at all times in bringing forward esparto to the mill, so that different brands and consignments do not get mixed. One consignment of esparto ought, if possible, to

be started and finished before another parcel is broken upon, both upon principles of economy and order, because you thoroughly come at once to the exact quantity of chemicals necessary to boil it in a satisfactory manner, and you also get at the actual merits of the parcel; while, if you start upon a lot and leave it unfinished, it may get mixed up with other brands, which in all probability puts your boiling all wrong, and the result is "re-boils," and consequently loss of chemicals. This might be avoided by ordinary care, and a fair understanding of the material and its treatment that will enable one to make the necessary change in chemicals to get the desired result, which is a necessary and desirable accomplishment in those connected with the bringing forward and treatment of the raw material.

Examination of Esparto.

Esparto, like other goods, is liable to be received otherwise than according to contract entered into as to quality; hence the necessity of a systematic process of examination being instituted. The following we consider a fair and honest system if properly carried out, and will cast discredit on none concerned. Upon a consignment of esparto being received at the mill, a few bales of the worst-looking and a few of the best-looking, judging from external appearance (which is not a very easy matter, but requires the experienced eye to detect them), ought to be put to one side for examination; then a bale ought to be taken from each truck, of the fair average quality, also for examination—the former with a view to ascertain the two extremes of the parcel, the latter to judge of the stock in a general way. The first mentioned ought to be hand-picked, and the im-

purities carefully examined and weighed, which will give an estimate of the nature of the impurities and the quality. Upon comparison with sample, or with conditions of contract entered upon as to quality to be expected, you at once know whether you are being supplied with the article or not. This system, or one equivalent, should upon no pretence be neglected, as all disputes, as a rule, are settled by arbitration; and such a system cannot raise suspicion of an unfair selection of test bales from the general stock, but leaves the whole matter plain and upright. It also establishes a thorough system of examination, thereby enabling those interested to come to a perfect knowledge of the different espartos, and also giving those in charge an opportunity of judging the material with considerable accuracy in case of dispute or difficulty.

Inferior Esparto.

There are various sorts of esparto which are considered inferior by the papermaker, and are sometimes rendered a cause of dispute between him and the esparto merchant. One of these is what is commonly called brosa esparto. The term "brosa" means gatherings, and is perfectly understood in the trade to consist of rakings, roots, and general refuse of the field. The receiving of such is a very unprofitable speculation for the papermaker. However, it is made up of such, and sold as such. Sometimes it is to be found amongst a parcel of superior goods, and when such occurs it is a source of much trouble and anxiety to the papermaker and the esparto merchant, leading to the introduction of outsiders into the transactions of respectable firms on both sides, which is much to be deplored, although periodically

necessary in the interests of those concerned. The fault generally arises from the carelessness of the packers, or it possibly might be called a species of adulteration, wilful or accidental. However, it does occur, and it is the duty of those interested to see to these things, with a view to abate the nuisance, if not wholly prevent it.

Another source of annoyance is weedy and rooty esparto, which, when liberally distributed over a consignment, is attended with considerable expense in removal, and loss to the papermaker, as these roots and weeds cannot be utilized, as they do not soften in the boiling, and consequently show up in yellow sheivy specks in the paper.

Again, there is a dead or black esparto, which is frequently to be found mixed with the good article in abundance, and is possibly caused by the esparto being put up damp before baling. It is seldom removed in the sorting department, consequently it goes as weight to the boilers, but is completely lost in the boiling, in consequence of the fibre being rotten or dried up to such an extent that in the boiling process it gets into a fibreless, sludgy matter, which passes off in the draining of the boiler after boiling.

The above evils are sufficiently annoying to the papermaker; but we think, of all the annoyances he has to contend with, heated esparto is the worst.

Esparto which has been saturated with water, in whatever form, either accidental or otherwise, will first heat in the bale, and, if allowed to proceed, will mat and stick together, and get of a white mouldy appearance, changing in time to a dirty grey or black colour, and will eventually begin to rot. If allowed to remain in bale and not immediately used, it will in a comparatively short time be rendered perfectly useless as a papermaking material.

In summing up the various difficulties, and the sources whence they spring, which the papermaker has to contend with in the selection, subsequent care, and periodical examination of his raw material, there are some which are very difficult to prevent, and others which, by the exercise of proper care and the adoption of preventive measures, with a due regard to unremitting and scrupulous cleanliness, might be almost entirely avoided, thereby smoothing the way, and keeping the goods in their natural clean state, or at least with less pollution than generally occurs.

Sorting and Dusting Esparto.

Esparto of all kinds contains a certain amount of dust and sand, independent of the dirt taken up as previously mentioned, which require to be separated as much as possible under the different systems in use for doing so.

At a very recent period in the history of esparto, all the sorting and dusting were done by hand in the following manner:—Tables were fitted up conveniently high for an ordinary-sized woman to work comfortably at: these tables were covered with iron or galvanized wire netting with half-inch mesh, to allow any impurities to pass through in the sorting process; the esparto was opened up upon these tables to facilitate the removal of roots, weeds, heather, and other impurities, and then made up into bundles or put in bags, and conveyed to the boilers.

In due course, papermakers began to see, from the quantity of roots, weeds, and other impurities—especially sand and small stones—escaping with the material supposed to be picked, that some change in the system was absolutely necessary to produce the

sufficiently clean article desired, hence they began to look abroad for some mechanical means of cleaning the esparto in a more efficient manner.

The first which came under our notice was a thrashing machine, on a small scale, which effectually removed the sand and dust; but the great difficulty of exhausting or carrying off the dust, which gathered in clouds, polluting the atmosphere of the dusting-room to such an extent that the workpeople could not breathe in it (this evil not being overcome by ordinary ventilation), caused this machine to be abandoned. Another machine has been invented, which not only effectually removes the sand and dust, but mechanically exhausts it by means of an exhaust fan applied to the under side of the willow, consequently leaving the dusting-room perfectly free from dust.

We will now endeavour to describe this willow: its construction and efficiency.

Description of Esparto Willow.

This machine is upon the conical principle, and of the following dimensions:—8 ft. 4 in. long (inside measurement), 4 ft. 3 in. diameter at widest end, tapering to 2 ft. 6 in. at narrowest end. It has a grating surface of 6 ft. and 8 ft. 4 in. for the purpose of carrying off the dust and other impurities of a like nature. Inside, and at the extreme top of the conical shell, is a row of stationary teeth — twelve in number — extending the full length of the shell, for the purpose, in conjunction with the revolving cone, of separating and agitating the esparto so that the sand and dirt will be thoroughly dislodged from it. Inside this shell is a revolving cone of cast-iron, provided with five rows of teeth—twelve in each row—extending the

full length of the cone, and equidistant from each other. The cone is 8 ft. long from extreme to extreme, 3 ft. 4 in. diameter at wide end, tapering to 16 in. at narrow end. The under grating is completely enclosed by woodwork, to which is attached a pipe connected to the exhaust fan, which exhausts the dust and discharges it into a separate chamber, to be removed periodically as required.

When the willow is in position and in condition for work, the esparto is fed in at a door at the top of the shell, and at the narrow end, almost as fast as one can conveniently do. The great speed at which it revolves enables it to toss and open up the esparto, and discharge it in a clean and dusted condition. This willow is capable of cleaning, in an efficient manner, 20 tons of esparto per day. As it has so few working parts, it cannot get out of order if sufficiently lubricated and ordinary care is exercised in the working of it.

Boiling Esparto.

Having willowed and dusted the esparto in an efficient manner, we will now proceed to boil it.

In describing this department of a modern paper mill, we desire to impress upon the minds of those employed in it that much depends upon their care, and also in the carrying out of orders given, paying attention to the regularity of the steam supply, allowing no leakage at steam joints, steam valves, or boiler doors, or at any other place where steam or chemicals can be wasted.

If the necessary precautions are taken to ensure a perfectly-boiled material at one operation, it will become much lighter and more comfortable for the workmen, and more profitable for the manufacturer,

as re-boiling is an expensive operation, and the seldomer done the better for all parties concerned.

The boiling-house ought, if possible, to be roomy and well ventilated—the ventilation arranged in such a manner that condensation of steam will not take place. The best constructed ventilators are those which can be opened when filling in the boilers, and shut again when the boiling-house is free from steam, which accumulates to a considerable extent when the filling in of the boilers is going on. Where there is insufficient ventilation, windows and doors should upon no pretext be left open for the purpose of ventilation, as dust and dirt of various sorts are scattered about in windy weather; consequently the boiling material, being in a wet state, is rendered a fit receptacle for it.

We will now suppose that the boilers are empty. Examine the false bottom: if the perforations are choked, or partially so, have them cleaned at once; if the boiler is encrusted, clean it also. This being done, run in your liquor, and bring it to the boiling point; then commence to fill in your esparto, taking care, if possible, to cross and re-cross it in such a manner that the lye will freely circulate through it, and penetrate to the very heart of the boiler. Having thus filled in the desired quantity, shut up your boiler doors, turn on the steam full, and, when this is done, the boiling process may be said to have commenced.

Having begun to boil, you now proceed to keep a record of the time of boiling, and of the varieties of steam pressure, with a view to judge of the result.

The esparto being boiled in an efficient manner, we will now proceed with the discharging or emptying, in the following manner:—Shut off the steam, open the blow-off tap, and, when almost blown off,

open the tap to the evaporating pans, and allow all the spent liquor to run off; now shut the tap on the blow-off pipe, and also the tap to the evaporating pans; then fill up the boiler with hot water for the purpose of washing the esparto; when full, shut down the lid of the boiler and turn on the steam full, and allow it to boil for about twenty minutes or half an hour. When this second boiling or washing is accomplished, shut off the steam, blow off and run off the water to the settling ponds, as we do not find from experience that the liquor from this second boiling pays for the fuel required to evaporate it. When completely run off, fill up with cold water for the purpose of cooling, and, when sufficiently cool, commence discharging, which is generally done into boxes and conveyed to the washing engines. This introduces us to another department in the manufacture of paper.

Esparto Boilers.

There is no requisite in a paper manufactory which has undergone so many changes as the fibre boilers. They are of two sorts—the Rotary and the Stationary Boiler. Several advantages are claimed for both. First, the stationary boiler occupies much less space than the revolving, and it requires no driving power; but it is doubtful if it does its work better and more economically than the revolving one. There is a stationary boiler in operation which has come under our notice, capable of boiling fifteen tons of esparto per week very economically; it occupies very little space, considering its capabilities. It is dome-shaped, 10 ft. high by 7 ft. 3 in. in diameter, and upon the vomiting principle, the vomit differing from others in being upon the double action—

that is, acting from above as well as from below—which has a tendency to ensure the material being thoroughly penetrated by the boiling liquor, consequently producing a uniformly boiled material.

Owing to the present requirements of the paper-maker, it is necessary to have the esparto in as soft a state as possible consistent with the cost; and our opinion, based upon experience, is, that revolving boilers of the spherical type are the best for the purpose of boiling either rags or esparto, provided the material to be boiled is completely covered with the boiling liquor. It prevents the possibility of the material settling down tight in the boiler, which is the case even with the vomit applied to stationary boilers. If covered with the liquor, the material is held in a loose or floating condition, thereby facilitating the action of the chemicals upon the whole mass, consequently enabling the boiling process to be conducted more expeditiously and economically.

Chemicals necessary for Boiling.

Esparto, if indifferently boiled, produces a paper which does not finish well, and at best looks a raw, sheivy, poor-looking article. Hence the desirability is evident that the material ought to be well boiled, and this cannot be done without the necessary chemicals, which are as follows for the different kinds of esparto:—

Fine Spanish,	18 to 20 lbs.	of 70 % Caustic Soda	per cwt.
Medium do.,	16 to 18 lbs.	,,	,,
Fine Oran,	18 lbs.	,,	,,
Medium do.,	16 to 17 lbs.	,,	,,
Susa, -	18 lbs.	,,	,,
Tripoli, -	19 to 20 lbs.	,,	,,
Sfax, -	20 to 21 lbs.	,,	,,

These figures ensure a first-class boiled material with the steam pressure at 25 lbs. and not exceeding 30 lbs., but are liable to alteration according to circumstances—such as the form of boilers in use, the quality of the water for boiling purposes, and steam facilities, which ought at all times to be steady and uniform to get the absolute regularity required.

Recovering Apparatus.

The spent lye discharged from the boilers is subjected to a process of evaporation, and subsequent roasting, with a view to recover the soda contained therein, in the following manner :—

There are various kinds of recovering plant, but the most economical in fuel, wear and tear, superiority of ash recovered, small cost of construction, etc., is one which has lately been patented, and has been adopted by some of the largest and finest mills in Scotland. This is a sure evidence of its superiority.

The advantages claimed are, full utilization of the heat—it being constructed upon such a principle that by the time the flame and heat pass over and under the pans and through the side flues, it is expended and fully taken advantage of. The recovered ash is conveyed to suitable chambers and allowed to burn out, when it is taken to the dissolving tanks for the purpose of being prepared for the boilers, in quantity as follows :—8 cwt. recovered ash, $4\frac{1}{2}$ cwt. of good lime, which produces 900 gallons of lye to stand 11° Twadd. It is then pumped from the dissolving tanks to the settling tanks, and supplied to the boilers as required.

Reducing to Half-Stuff.

The engine most in use for washing and reducing esparto to half-stuff is of large dimensions, and capable of containing one ton of esparto. It is made of the shape of the ordinary engine, but without a plate, and the roll and bars are of one casting, as esparto can be reduced to half-stuff by the simple action of the roll without the bedplate, consequently the roll is stationary as far as the lifting and lowering are concerned.

In the bottom of the engine there is also a sand-trap for the purpose of catching and retaining any sand which may have escaped previous cleansing, or which may have been caught up in process of manufacture; it is covered over with a zinc plate perforated with small holes, through which the sand passes, allowing the clean stuff to circulate in the engine. The engine is also provided with a drum or cylinder washer, for the purpose of carrying or discharging the dirty water in quantity equivalent to that of the clean which runs into the engine.

We will now commence the filling in and washing operation, as follows:—Fill up the engine about three parts full of water, let down the washing cylinder, and begin filling in the esparto until there is a sufficient quantity, which ought never to be thick and difficult to turn, as by doing so the esparto is insufficiently washed, and occupies more time in the washing process.

When the proper quantity is introduced, regulate the water so that the clean running in is equivalent to the dirty discharged. The washing process being in full operation, you commence to stir up the esparto with the paddle, drawing it along the sides of the engine to prevent the material settling down and escaping the washing process, as it is

most important that all the stuff should circulate in the engine so as to ensure a perfectly washed, and consequently perfectly bleached, material.

The washing being concluded, shut off the supply of clean water, and allow the drum-washer to continue working until sufficient space is left for the introduction of the chlorine.

Bleaching Esparto.

The bleaching of esparto is generally performed in the same engine in which it is washed, in the following manner:—In close proximity to the engines is a stone tank, with an outlet pipe to the engine, and an inlet pipe from the chlorine reservoir. This tank is accurately measured, and the cubic contents ascertained, then a measuring gauge, indicating the contents in inches in depth (which consequently gives the number of gallons per inch), is fixed inside the tank, and the man in charge has only to run up the liquor in the tank the number of inches ordered for the different materials to be bleached (as he is periodically ordered by the manager or foreman); which quantity ought never to be exceeded, both upon economical principles in saving chlorine, and also in preventing injury to the material.

The chlorine being introduced, allow it about half an hour to thoroughly come in contact with the fibre, then introduce the vitriol, taking care previously to dilute it, adding the vitriol to the water, not the water to the vitriol—the latter process causing excessive effervescence and a most disagreeable smell.

The quantity of chlorine and of vitriol necessary to bleach esparto in an efficient manner depends upon how the material has been boiled, and how the esparto has been washed. If both are sufficiently

well done, the following quantity will be found to bring it to a satisfactory colour :—

Spanish Esparto.—6 lbs. of bleaching powder made into a liquor to stand 6° Twadd. per cwt., adding 6 oz. of vitriol per cwt.

Oran Esparto.—7 lbs. of bleaching powder, as above, and 8 oz. of vitriol. The other qualities of esparto, 8 lbs. of bleaching powder and 8 to 9 oz. of vitriol.

Having washed, reduced to half-stuff, and bleached the esparto, it is emptied into reservoirs provided with agitators, for the purpose of mixing and keeping the half-stuff from settling to the bottom of the reservoir. Previous to the introduction of the reservoirs the half-stuff was emptied into stone chests and drained by perforated drainers.

We will proceed with the most modern method, which is adopted by all well-regulated mills, viz. :

The Half-Stuff Machine.

This machine has been brought to a high state of efficiency; it not only dispenses with a bleaching house, but is a labour-saving machine to such an extent that the first cost is soon recouped. It is upon the principle of the wet end of an ordinary paper machine, consisting of two or more stone chests for the reception of the half-stuff, fitted with agitators for the purpose of keeping the stuff in a proper condition.

The stuff is pumped from these chests and discharged into a mixing box, thence over a variety of

sand-traps, which are constructed of wood, and fitted with slips of wood fixed in the bottom of the trap, for the purpose of retaining any sand or heavy dirt contained in the stuff.

The stuff now passes into the strainers, which are the principal cleansing agents of the half-stuff machine. The strainers are in number according to the capacity of the mill: for example, one strainer fitted with No. 5 and No. 6 cut plates is capable of straining half-stuff in an efficient manner for 20 tons of finished paper per week. The strainers are of the flat type, self-cleaning, and upon the disc principle;—self-cleaning, because the plates are continually undergoing a cleansing process by the application of two perforated pipes across the strainer, which thoroughly washes the impure stuff towards the outlet end of the strainer, where it escapes by a waste pipe, whence it is conveyed to an auxiliary strainer, which retains the impurities, and discharges the clean stuff into the original chest. Underneath the plates, and in the extreme bottom of the vat, are two holes of an oval shape, fitted with a rubber flange, and attached to this flange is a cast-iron disc connected to a crank motion, which has a speed of about 600 revolutions per minute, which keeps the plates perfectly clear, and allows the strained stuff to pass freely through the plates, and retains the impurities upon the upper surface until the perforated pipes wash them clean off the plates. The strained stuff now passes on to the wire-cloth, and is conveyed across two vacuum boxes, which are connected with four powerful vacuum pumps; this operation makes the half-stuff sufficiently dry. To be handled with ease, it now passes between the couch rolls and on to the felt, and is run into webs or discharged into boxes, as the case may be.

Beating or Refining Department.

This is a department of a paper mill where none but thoroughly efficient men should be employed, for it is here that the paper is really made—that is, the quality of the paper produced at the paper machine will be in proportion to the treatment the material has received; and if the half-stuff sent to the beating engines is not subjected to judicious manipulation and careful preparation for the especial paper to be made, all future doctoring will prove unsatisfactory. A careful and experienced machine-man may possibly help badly-prepared stuff, and make the paper pass muster, but that is not sufficient. Hence we will endeavour to explain how it is possible to avoid these evils, and prepare the stuff for the various papers so as to give satisfactory results.

To prepare stuff for extremely thick and extremely thin papers (which are the general run) with the same preparing facilities, is no task for the novice; the production of good work is simply a question of time, as the thin papers require careful drawing out into clear fibre, while the heavy papers necessitate smarter treatment to prevent the stuff softening or greasing, thereby carrying too much water, and rendering it necessary for the paper machine to run at an extremely slow speed to produce a satisfactory paper.

The speed of the beating engine and the quality of the roll bars and plates must also be taken into consideration. A beating engine ought never to have less than 220 revolutions of its beating roll per minute, and the roll bars and plates ought to be of fine mellow steel, not hard and brittle, nor soft and iron-like, but a tough and well-tempered article.

The beating-room ought to be roomy, thoroughly clean, and well lighted. Facilities ought to be provided for the thorough straining of everything entering the engine. This straining ought to be rigorously carried out, as a very minute particle of dirt escaping with the stuff, on being subjected to the pressure of the glazing calenders, soon appears large enough to make the otherwise perfect sheet into retree; this small dirt is also most troublesome, as no straining at the paper machine will keep it back. Hence the absolute necessity of this careful straining of size, alum, starch, china clay, and all descriptions of colouring matter through fine mesh wire-cloth, fine flannel or tap bagging, and, in some cases, through silk.

Before entering into details of the most modern beating engines, we will endeavour to describe the engine universally used; and as the latest inventions in these engines are but yet in their infancy, and have not been generally adopted, it would be premature to give them a first place and abandon the old.

The present type of engine in general use is what is termed in the trade the 400 lb. engine, it being of that capacity. The trough is of cast-iron, 13 ft. 6 in. by 6 ft. 6 in., and dish-bottomed—that is, the sides are not perpendicular inside, but rounded at the bottom, giving the bottom of the engine a dish shape, thereby leaving no square corners for the reception of what is termed "lodgers," or settled stuff, which, if prevented circulating in the engine, would leave it unprepared; hence it would form into hanks and knots at the machine strainers, causing imperfect paper. It is provided with a cast-iron roll 3 ft. 6 in. by 3 ft. 6 in., having sixty-nine roll bars placed in bunches of threes; this roll is

hung upon a malleable-iron shaft 5 in. in diameter, which rests upon side levers, and by a uniform lifting gear the roll can be lifted or lowered at pleasure, the lifting and lowering being equal on both sides. Directly under the roll is the bedplate, consisting of twenty steel knives, corresponding in length to the roll. If they are straight they are fitted into the plate box at an angle, but those generally used are what are termed in the trade the elbow plates; these are bent in the centre, the angle running to both ends of the roll.

This completing the beating engine now in universal use, we will commence operations and prepare the stuff for the paper machine; but before entering upon the details of preparing stuff for the different papers in use, it will be necessary to describe the art of blending the raw materials to get the best results.

There are two modes of blending—namely, blending the material in the raw state, or the rags, before boiling, and blending the half-stuff in the beating engines. Blending the different rags is convenient where space in the bleaching department is limited, but, where sufficient space is available, blending in the beating engine is best. It is perfectly understood in the paper trade, that what is required of the papermaker is to produce as close, even, and uniform a sheet as possible, and this can only be accomplished by judicious blending of the materials used, and by judicious manipulation. For example: esparto does not work well with rags where the esparto predominates, in consequence of the esparto being reduced to the necessary consistency before the rag stuff is fine enough, consequently the rag admixture shows up in knots and threads in the paper. If, on the other hand, the rag stuff predo-

minates, the treatment is as for rag stuff; and in process of preparation the rag stuff is reduced to the desired length of fibre, while at the same time the esparto stuff is reduced much finer, which is termed the process of filling or incorporating with the sheet, to ensure its closeness.

There is another system which is very difficult of accomplishment—that is, preparing the rag stuff and esparto stuff separately, and mixing the two after preparation in the paper machine chests, where they are thoroughly mixed with each other before passing on to the machine; but this system cannot well be adopted, as it is most difficult to keep the blend equal—that is, having a constant uniform quantity of the admixture entering into the manufactured paper.

Stationers and printers have special requirements, which the papermaker must endeavour to meet. In some cases they demand a soft paper, which can only be given by a judicious blending of esparto and old worn cotton rags, and smart treatment in the beating engine. Again, for other purposes, a hard, firm paper is required, which necessitates considerably more expensive material and manufacture to produce it. Hence the absolute necessity of blending and preparing the material according to the especial paper desired.

We will now commence to prepare the stuff for the paper machine. First see that all the strainers are in good condition, put a clean filtering bag on the water-tap, then turn on the water, and allow the engine to fill about three parts full before introducing the half-stuff. We will suppose that the roll bars and the plate are sharp, and we are about to treat the material furnished for thin paper. The roll must be let gently down upon the plate, never

allowing it to bear hard, but skiffing and drawing out the fibre without cutting or chopping its texture, which with sharp tackle is most difficult of accomplishment, and requires the utmost care and attention. On the other hand, if the roll bars and plate are comparatively blunted by use, more freedom can be used in the letting down of the roll, as partially blunted knives are not so liable to cut up the stuff and permanently injure its texture, and are consequently best adapted for the preparation of thin papers.

Extra heavy papers require sharp tackle, as the blunted knives would not prepare them in sufficient time to prevent the stuff getting soft and greasy, and rendering it, if not impossible, exceedingly difficult to work at the paper machine.

The engine being filled in, neutralize any remaining chlorine, as, if this is not done, it will act upon the stuff and injure it in colour and texture, even after being manufactured into paper. It is also necessary to neutralize the chlorine to prevent the sizing ingredients being injured, which is especially the case in animal-sizing. The chlorine can be expeditiously and permanently destroyed by the use of hyposulphate of soda, which immediately combines with the chlorine, forming sulphate of soda.

The material must now be treated according to the condition of the tackle, and according to the thickness of paper to be made.

Now introduce the loading, if any. At this point it may be mentioned that much has been said in and out of the trade about the use of loading in the form of china clay, but our experience in the manufacture of high-class and ordinary papers, writing and printing, is, that the judicious use of china clay has given

the consumer a better-filled and closer sheet, which takes a better surface; it is also stronger, because longer-drawn fibre can be made into a close sheet by the use of a little clay, thereby giving more strength, or at least compensating for more than is lost by the use of the clay. First-class mills do not exceed from 10 to 15 per cent., according to the class of papers required.

The loading being introduced and thoroughly mixed, next introduce the sizing agents (which consist of alum and rosin soap) in sufficient quantity to size, according to requirements. 16 lbs. of rosin, 8 lbs. of crystal soda, and 35 to 40 lbs. of alum, are, under ordinary circumstances, sufficient to hard-size 400 lbs. of finished paper. The size being introduced and thoroughly incorporated with the stuff, put in the colouring matter, which ought to be in quantity according to shade required.

The weighing or measuring of size, alum, and colouring matter ought to be conducted upon the most accurate principles possible, as it is absolutely necessary for the papermaker, in producing a given shade, to know the exact quantity to enable him to repeat the order with accuracy. This is especially necessary in paper made up into book form, as two or three different shades in one book injures its appearance. In the process of beating, the stuff requires to be frequently stirred and mixed with the stirring paddle, which has a tendency to prevent it from settling down to the bottom of the engine, thereby leaving it unprepared.

The engine of stuff being now finished, it is emptied into the machine stuff chests, where it is thoroughly mixed previous to its manufacture into paper.

Modern Beating Engines.

Beating engines of the most modern type have been put in the market of late years, all claiming improvements as to economy and efficiency. One of recent manufacture, which is in operation in the Government mill at St. Petersburg, has given the greatest satisfaction, the workmen affirming that it is superior to any other, as it performs its work quicker and cleaner, and gives a more uniform quality in consequence of the stuff travelling without depositing "lodgers." It also occupies very little floor space, considering its capacity.

PAPERMAKING MACHINES.

These machines are at work at the present time varying in width from 50 in. to 120 in., papermakers considering that there is more economy in a wide machine, as it only requires the same attendance as a narrow one, and, taken in comparison, less power to drive it.

The paper machine of to-day is a thoroughly complete piece of machinery, finishing the paper in a most efficient manner. We will endeavour to describe all its parts—their working, use, and keeping in order—so as to get the best results.

Stuff Chests.

These are generally made of cast-iron, cast in plates, fitted and bolted together, and of a convenient

size to suit the requirements of the mill, but generally 12 ft. in diameter and 6 ft. deep, and provided with agitators for the purpose of mixing and keeping the stuff of a uniform consistency. The speed necessary for the agitators is about ten revolutions per minute, which mixes the stuff sufficiently without knotting it. In the extreme bottom of the chest is a washing-out pipe, which ought to be connected to the save-all, as sometimes stuff can be caught, which may be disposed of for re-manufacture into wrapping paper.

Stuff Pump.

This pump is generally of a 6 in. bore of barrel, and lined inside with copper, having a brass plunger, and an arrangement of brass ball valves. It ought to be kept in good condition, the valves periodically examined and the top gland packed, as it is very important that the pulp should at all times be in excess of what the paper machine is using. The stuff is pumped from the stuff chest by this pump and discharged into a supply box, which is provided with an overflow pipe; this conveys any superfluous stuff back to the chest, thereby keeping the stuff in the supply box at a uniform height, and supplying an equal quantity to the machine. These pumps are generally of the single-acting type, having two copper-lined barrels and rubber valves, and are connected to the size-water box standing upon the same level with the machine save-all, and discharging the size-water into a box above the level of the sand-traps, where it discharges through a regulating pipe, in quantity to suit the requirements of the machine, into the stuff box, and thence into the sand-traps.

Sand-Traps.

Sand-traps are generally constructed of wood, and of a size and form to suit the space at disposal. A first-class one can be made as follows, if sufficient space is available :—Size : 14 ft. long by 8 ft. wide and 8 in. deep, all inside measurements. This trap is divided into four runs or compartments, covered in the bottom with old first-press felt, on the top of which are slips or bars of iron or lead, for the double purpose of keeping down the felt and retaining sand or other heavy dirt. The trap is now hung upon a strong beam of wood right in the centre, and supported by four legs on hinges. When it requires washing, simply remove the slips or bars, swing over the trap and wash out, which can be done in a very few minutes.

In a box attached to the inlet of the sand-traps are two supply taps—one for stuff, and the other for water : the stuff and water being turned on, they flow over the sand-traps and fall into the strainers.

Strainers.

Modern strainers are of various kinds. As every inventor claims to be in advance of his fellows, to enumerate all the strainers in the market would fill an ordinary-sized volume, and when done would only lead to confusing the good with the indifferent; consequently we will confine our investigation to the "revolver" and the flat improved strainer.

There have been many recent improvements in the construction of revolving strainers, one of which we select for notice, it having gained the approval of many paper manufacturers. The whole inside is enveloped in a sheet of rubber; this rubber receives

its vibratory motion from a pump arrangement, which, being perpendicular, is not liable to get out of order; the motion from this rubber sheet extends over the entire under surface of the plates, thereby rendering every inch of plate surface available for passing stuff.

The straining power necessary to pass and clean pulp in an efficient manner for 25 tons of finished paper per week is two revolving strainers, consisting of four rows of plates, or 7 ft. by 18 in. of straining surface on each of the four sides, the plates being cut No. 2½ Watson's gauge. The stuff passing through these strainers is conveyed by an open shoot into a breast strainer of the flat jog-motion type. This flat strainer is provided with plates with a wide cut (generally No. 5 of Watson's gauge), and, being used only for breaking up the stuff, it does not require to be provided with close-cut plates. The stuff passes through this breast-strainer and on to the paper machine wire.

Paper Machine Wire and Connections.

This is the most important part of the paper machine, and one which will require some description to make it understood. The wire frame ought to be strong and rigid, and able to carry a wire not less than 40 ft. long; it is provided with a strong sole-plate of cast-iron, with malleable-iron side bars and supports, with cast-iron shake stands fitted with brass socket shake joints; the frame, which is of malleable-iron, carries a copper or brass breast roll 18 in. in diameter, a guide roll 7 in. in diameter, and four rolls (under the wire) 5 in. in diameter, all of brass or copper, with the spindles extending through the rolls, and provided with brass bushes and brackets

and a self-acting guide upon the 7-inch guiding roll, tube rolls (or carrying tubes) of brass, with malleable-iron ends, carried upon brass bearings; these tubes must be of sufficient strength to carry the wire flat and straight without yielding. Alongside the wire framing, and bolted on to the sole-plate, are three strong cast-iron stands on each side, for the purpose of carrying the save-all under the wire. On the top of the wire, for the purpose of regulating the width of the paper, are a set of brass deckles, carried on a brass frame passing over the first vacuum box, and supported on the wire frame by means of malleable-iron studs fixed in the frame, and at the two extreme ends of the deckle frame are two pulleys for the purpose of carrying the deckle strap, with three similar pulleys for the purpose of expanding it, the end pulleys being somewhat larger for the easy working of the strap. This deckle frame is provided with two indiarubber deckle straps, endless, and working into these flanged pulleys.

Inside the wire, and under the wire frame, are fitted two vacuum boxes made of wood, open at the top, and lined on the edges with black vulcanite, and having moveable ends upon copper or brass screws for the purpose of altering according to the width of the paper required; these boxes are also provided with air-cocks for the purpose of regulating the vacuum. Connected with these boxes are two sets of vacuum pumps, consisting of three barrels (6 in. bore) to each set, and copper-lined, with brass buckets and rubber valves, arranged to work attached, or a set to each vacuum box, the draw or suction being regulated by the before-mentioned air-cocks and the cocks upon the main pipe, which pipe connects the boxes to the vacuum pumps. At the extreme end of the wire from the breast roll

is the under couch roll, inside the wire, and carried upon strong cast-iron framing, fitted with brass bearings. The bottom couch roll is generally 14 in. in diameter, made of brass, which is ground to a working joint with the 20 in. top roll, both being covered with seamless woollen jackets.

We will now proceed to put on an endless web of wire-cloth, for the purpose of carrying forward and moulding the paper. Remove all the tube rolls, carrying rolls, save-all, and deckles, lift up the end of the bottom couch roll, having previously taken off the top couch roll; slip on the wire-cloth, and let down the bottom couch roll; then commence to unroll the wire-cloth towards the breast of the machine, and then pass through the breast roll; now put in the vacuum boxes, and connect them to the vacuum pumps, then the save-all and tube rolls, and the leading and stretching rolls, taking care to leave the stretching roll easy in the brackets; now drive round the wire-cloth and examine for blemishes—(if any, take a note of them); now put on the top couch roll, and tighten the wire just sufficient to take off the slack, but upon no condition to rack and stretch the meshes of the wire-cloth. This being done, run the wire while the strainers are being filled up, as by doing so you help to firm the bottom and top coucher jackets, which, when both are new, prove troublesome with padding, or sticking.

The wire being in good working condition, and the deckles set to the desired width, turn on the water and stuff, and, when it runs about a third on to the upper surface of the wire-cloth, start the wire, and the paper will pass through the couch rolls and on to the wet felt, passing beneath the press rolls and running up the roll until it is checked by a cleaning knife across the top of the roll; allow the paper to

run up the roll until the back water comes round in sufficient quantity to keep the inlet flow equivalent to the outlet. Now put on the dandy roll, which is made "wove" and "laid," the wove being plain woven wire-cloth of 66 mesh, and the laid composed of horizontal wires varying in closeness according to the fineness of lay required.

The dandy roll now being on, and the water and stuff regulated, we will pass on to the first press rolls.

First Press Rolls and Connections.

These rolls are of various sizes and of different metals, but the following is the rule :—Under roll 14 in. in diameter and brass jacketed, top roll 16 in. in diameter, also brass jacketed, but the top roll in some cases is of close-grained cast-iron; both rolls are ground to a working joint, with the desired working pressure. On the top roll is fitted a travelling doctor: when this roll is made of brass the doctor blade is also of the same material, but if it is cast-iron the doctor blade is steel. Between the press rolls and over a series of wooden ones is an endless felt travelling round with the former for the purpose of carrying the paper through between the press rolls, where it is subjected to the desired pressure, which ought never to be so great as to leave the impression of the felt on the paper.

Second Press Rolls.

The paper now passes backwards through a second set of press rolls similar to the first set, but, the paper being reversed, the surface is consequently given to the under or wire side of the paper. The use of the second press rolls is very important in producing an equal surface on the paper: by judi-

cious pressure with the second press rolls the wire marks are considerably lessened, thereby giving both sides of the paper a comparatively uniform surface.

The Cylinders.

The paper now passes on to the first section of cylinders for the purpose of drying. The first section generally consists of seven cylinders 4 ft. in diameter, and of a width on face to suit the widest paper made. These cylinders are properly gauged for the contraction of the paper, consequently giving a uniform draw through the machine. They are driven by means of wheels keyed on to the end of each cylinder, geared into each other, and receiving their motion from a series of back-shafting fitted with pulleys and driven with belting. The drying steam enters from the front side of the cylinders, and the exhaust escapes by the opposite side. The first two are bare, while the other five are covered with cotton felting, for the purpose of preventing the paper from rising in blisters, or what is technically called "cockles." Cotton felting is best adapted for the first section of cylinders, as it stands the damp best, and consequently runs longer.

The paper passing over the first section is subjected to the first drying process, which should not be of high temperature: the best mode of procedure is to have the first cylinder cold, and the rest gradually heated up to the end of the machine. After passing over the first section the paper passes through the smoothing rolls: this being the first bare-roll pressure the paper is subjected to, it is very desirable that it should contain the proper amount of moisture to get the best results.

The smoothing rolls consist of two chilled-iron rolls of 14 in. diameter, ground to a close joint, and

provided with steel travelling doctors, and heated with steam upon the same principle as the cylinders.

The paper now passes on to the second section of cylinders, which are all covered with felting, and heated to a higher temperature than the first section. The felts best adapted for this section are those made of wool, as, the paper being comparatively dry, they do not get wet, and in a dry state last longer than the cotton; as they are also of greater substance, they give the paper a more uniform and dry surface.

Glazing Rolls.

The paper, when passed over the second section of cylinders, is subjected to the pressure of chilled-iron glazing rolls, for the purpose of giving it the finishing surface, which is considerably facilitated by the introduction of a damping apparatus of very recent date.

At the finish of the last section of cylinders, and before the paper enters upon the calenders, is placed the damping apparatus, which consists of two brass or copper rolls of 14 in. diameter; a constant stream of cold water is passing through them, while finely-perforated pipes are blowing a continuous line of steam jets over the entire face of the rolls—the cold water in the rolls condensing the steam, thereby conveying a uniform moisture to the under surface of the paper, which enables it to take on a better surface when passed through the glazing rolls.

Glazing calenders are in position and number according to the requirements of the mill and the paper produced. Upon the introduction of American chilled rolls for glazing purposes they were fitted up in stacks of seven rolls, and sometimes as many as nine, which in all well-conducted mills have been

altered to four, not exceeding five rolls. The larger stacks did not give good results on account of their being placed in from seven to nine rolls, the one above the other, as the heavy pressure, acting on the paper directly it left the cylinders, crushed it, bringing the dirt to the surface, and giving the paper a thin feel. Consequently, to get the proper finish, we will place the calenders in a position to do so without crushing the paper, and without showing up the dirt in specks on its surface.

First, a set of three rolls, second set to consist of four rolls, and a stack of five to give the finishing or dry surface. With this arrangement of calenders, and the assistance of the damping apparatus, any desired surface can be got by varying and regulating the drying of the paper, which any careful machineman can do with ordinary care and attention. The paper having passed through the last set of glazing rolls, it is run upon a roll driven by friction and then conveyed to the cutting machine, to be cut into sheets of the size required.

Before leaving the paper machine we will describe in detail its working, going through all the items connected with it which may prove instructive and profitable to the reader.

Wire-Cloth.

This part of the machine is most fragile, and requires careful and delicate treatment. For fine papers the wire-cloth ought never to be coarser than No. 66, as, if so, an indelible wire mark is left in the sheet, which is very objectionable. To work a wire properly, and to prolong its time of efficient working, keep it comparatively slack and the seam straight, have the couch roll jacket tight-fitting, and

couch as light as consistent with the firming of the paper for the press rolls; do not start with a thick folded starting sheet, and keep the top couch roll jacket clean, which prevents licking up. If these precautions are taken, the wire is getting all the justice the machineman can give it.

Wet Felts.

Wet or first press felts are made of fine wool and of an open texture, to allow the water to pass easily. They are easily damaged, as a small piece of hard substance—paper in lump or otherwise—will cut a hole if it passes through the rolls. They are provided with a blue or red thread, which indicates the straight run of the felt; the two ends of this thread, when kept exactly opposite each other, indicate that the felt is running straight and uniform as woven.

Second Press Felts.

The second press is somewhat thicker than the first press felt, but ought to be somewhat of the same texture, as to get a uniform surface on the paper it is necessary to press considerably heavier with the second press; consequently, wherever there is pressure used at the wet end of the machine, a considerable portion of the water contained in the formed paper is discharged, and if at either of the presses it must pass freely through the felt,—hence the necessity of the second felt being similar to the first, as, where a good under surface is wanted, pressure must be used.

Cylinder Felts.

Cotton cylinder felts are best adapted for the first section of cylinders. Being always damp, they run more uniformly in that state, and do not bag and crease when run for a considerable time; when on the dry end of the machine they do not, however, give such good results, as they burn quicker, and generally give out at the seam. Woollen felts, on the other hand, when upon the wet end of the machine, bag in a very short time, and crease, which is caused by the middle being wet and the edges dry—the former expanding to such an extent that it is sometimes necessary, with a woollen felt which has been working for one month, to cut it at the edges and insert a piece to prevent the felt from creasing. The woollen felt lasts longer if on the dry end, as it does not burn so quickly, and keeps uniform until it is completely worn out.

Dandy Rolls.

The dandy roll is a very delicate requisite, and one that enters largely into the cost of a paper mill. A special room ought to be provided, with racks suited for their reception when not in use, as they are very easily damaged.

Dandies consist of laid and wove, plain and with name and devices; they are generally made to suit the width of the machine on which they are to work, and the names and devices are arranged upon the dandy according to the size of sheet required.

Plain wove dandies are covered with 66 mesh wire-cloth, and in the case of high-class thin paper the mesh is from 70 to 80. Plain laid dandies are various, ranging from 10 to 24 wires to the inch,

the coarser being used for heavy book papers, and the finer for ordinary and thin.

Named dandies, in either laid or wove, are only adapted for the particular paper for which they are made, such as foolscap, large post, small post, medium, demy, royal, super-royal, etc.—all requiring separate rolls to put the name or water-mark in the proper position in the sheet.

Belting.

A paper machine, like the majority of machines, must run uniform and steady in all its parts, consequently the driving belts must be kept moderately tight and in good order. It is not economical to work old and inferior belts; the most thrifty plan being, when a belt requires much patching and repairing, to replace it by a new one and use the old one for lighter work, which always can be had in a paper mill. Packing being necessary on the pulleys for regulating the draw of the paper, it should be put on evenly and never in lumps, which rack and injure the belt, thereby shortening its working time. When a belt gets stretched and unable to drive, shorten it at once, but upon no consideration whatever tighten it by increasing the size of the pulleys with packing, as a steady drive cannot be got by doing so, as the packing is always coming off, causing broken at the machine, and unsatisfactory work to the man in charge.

Having described the working, mounting, and keeping of the paper machine, we will proceed to cut the paper previous to entering the finishing department.

Paper Cutting.

There are various cutting machines in use for cutting plain paper, but the one we consider the best is the Revolving Cutting Machine, which has been brought to a high state of perfection.

This machine is capable of cutting eight webs of paper at once without the slightest variation of the size of any of the sheets, as follows :—Place eight rolls of paper on the framing provided for the purpose, lead through the under sheet between the two leading and through between the drawing press, then continue to lead in the upper sheets in rotation until the cutter is fairly feeding. The paper now passes between the circle or slitting knives, which cut it to the desired width, at the same time paring the margin ; it then passes through a pair of leading rolls and over the dead knife, where the revolving knife comes in contact with it, cutting it into the lengths required, the accurate length being got by the use of an arrangement of pulleys of different sizes for the regulation of the draw of the paper. Being cut, it drops upon a travelling felt or apron, where it is caught by boys or girls, and dressed up into heaps for conveyance to the overhaulers.

Sizing and Drying High-class Papers.

High-class machine-made papers do not differ in process of manufacture from engine-sized papers, only the finishing is conducted upon a different principle as far as sizing and surfacing are concerned. High-class papers are what is termed "animal-sized." This process of animal-sizing consists in giving the finished web a coating of gelatine to

render it non-absorbent, and also to give it a tough parchment-like feel and rattle.

A modern sizing machine consists of a wooden trough 14 ft. long, and in width corresponding to the widest paper. It is lined inside with lead, and provided with four leading rolls made of mahogany. The paper passes under and above these rolls, and through between a pair of brass shelled press rolls, for the purpose of squeezing out the superfluous size, and to permit of the sized paper being wound upon a roll at the back of the sizing machine, or passed directly over the drying machine. The quantity of size absorbed depends upon how the stuff has been prepared in the beating engines, fast stuff being very difficult to size, while soft or well-timed stuff sizes without any difficulty up to the Government standard.

The Drying Machine.

This machine consists of a series of drums, technically called "skeleton drums," provided with fans inside, which drive the hot air about the paper. Underneath the machine is a series of steam pipes, which supply the drying power.

The first twelve drums are not provided with fans, consequently the paper passes over about one-fourth of the machine without being subjected to a high temperature, as quick drying is undesirable, on account of its evaporating the size and generally injuring the quality of the paper. The paper being carried over the drums by means of tapes, the necessity of leading by hand is obviated. It is now run upon reels and conveyed to the cutting machine to be cut into sheets, whence it is put into a cold room, and allowed to remain in heaps or stacks previous to plate-glazing.

Plate-Glazing.

Previous to the introduction of zinc, high-class papers were glazed with copper plates, which proved very expensive, as the used-up plates could not be utilized, but were sold as old copper. Zinc suiting the purpose equally well, and being much cheaper, it is now in general use.

In order to give the paper an extra high surface, it is subjected to a pressure of twenty tons, and passed as often between the calenders as is necessary to get the desired surface; but the seldomer it passes between the rolls the better, as it is liable to get blackened if passed too often. Paper of the description called "antique" and "old style" is often surfaced with good cardboard instead of copper or zinc.

MECHANICAL DEPARTMENT.

To clearly comprehend the manufacture of paper, it will be necessary occasionally to introduce other matters closely connected with it. Hence it is absolutely necessary for the papermaker to have some knowledge of mechanics: this will enable him to decide in matters of importance connected with the machinery directly under his charge. We will therefore impart to the reader what little knowledge we have acquired in this department.

First we will give some details regarding water: its power and value as a motor.

Water was never more taken advantage of than at the present time. Manufacturers have found out its value, and engineers have met them in the most

liberal manner by inventing and improving water wheels which give the most satisfactory results. Wherever water is available it should be utilized up to its utmost capacity.

The most satisfactory turbines that have come directly under our notice are the "Hercules" and the "James Leffel," both of which are wheels of undoubted reputation and merit; and, to make them more intelligible to the reader, it will be necessary to describe them in order.

The "Hercules" claims superiority on account of its peculiar construction of buckets, which consist of projecting shelves cast on each bucket at intervals of one-fourth, one-half, and three-fourths of the height. The advantages of these projecting shelves are apparent. Suppose each bucket to hold one cubic foot of water: the gate is raised full up when this quantity is flowing in, but, should three-fourths of this quantity only be available, then the gate is lowered to the first projection, and the part of the bucket exposed is entirely filled; when only one-half of the water is available the gate is further lowered, and the upper half of the bucket is now completely shut off, while the lower half is quite full.

The actual power of 1000 cubic feet of water falling one foot is 1·9 horse-power, and by using a first-class turbine it will give out $1\frac{3}{4}$ horse-power. When the old system of wheels is compared, the loss in power is considerable: for example, under the above fall and quantity of water an undershot wheel gives $\frac{5}{8}$ horse-power, a breast wheel 1 horse-power, and an overshot wheel $1\frac{1}{4}$ horse-power.

A turbine of the Hercules type, with 10 feet of head, 7·1 cubic feet per minute, and 2460 revolutions, gives 11 horse-power; and with 10 feet of head, 12·3 cubic feet per minute, and 2850 revolutions, the result is 47 horse-power. The claims of

the various first-class turbines, therefore, are facts which have been proved by competent authority.

In taking advantage of the power of any stream, the first consideration is how much horse-power is available under the most favourable and the most unfavourable circumstances. When this is ascertained, the mean must be taken as a basis to work upon, and the capacity of the wheel must correspond with the mean supply of water. The mill race should be of sufficient size, both at inlet and outlet, to allow the water to pass freely to and from the wheel. The water at the inlet should not exceed a velocity of two feet per second, and the wheel placed about one foot below tail-water level, which adds to the available fall.

In measuring water to ascertain its power as to quantity and height of fall, there are special instruments for that purpose, but a simple and comparatively accurate system is as follows :—

Procure a piece of wood and load it until it floats level with the surface of the water (the loading must be from the under side), drop it into the mill stream or race, having previously measured off a given distance over which you wish it to float; note the time exactly it takes to float the measured distance: this distance, multiplied by the mean depth and width of the mill race, less 15 per cent. for friction, will give the number of cubic feet available in the time noted. In estimating the height of fall, it must be measured from the surface of the inlet to the surface of the tail-water, the additional foot the wheel is immersed adding to the available fall.

Steam Power.

In many mills where sufficient water is not available, recourse is had to steam; and in describing this

department it is necessary to begin at the steam boilers. These are, like every other requisite in a paper mill, of various sorts, but the one described below has given most satisfactory results.

The "Galloway" Boiler.

This boiler is well known in the paper trade for economy in fuel, quick steam-raising, and durability. It is generally 24 ft. long, 6 ft. 4 in. in diameter of shell, $\frac{3}{8}$ in. thickness of plate, and double riveted in such a manner that the rivet holes break joint in half the length of the plate, which avoids a continuous line of rivets. The flues consist of two furnaces 2 ft. 6 in. in diameter and $\frac{3}{8}$ in. plate; these two furnaces unite behind the fire bridges into one flue, which arrangement gives sufficient room for cleaning and examination. The tubes converging towards the centre, the lower ends are brought closer together, thus giving more strength to the flue, which is supported by 24 cone tubes, these being interchangeable. The boiler is capable of raising steam with the greatest dispatch, having a heating surface of 973 square feet, giving out 41·64 horse-power per cubic foot of water evaporated per hour. The wear and tear expenditure upon these boilers being reduced to a minimum in consequence of their substantial construction, they have a claim upon the notice of papermakers, who keep boilers almost constantly at work.

The Steam Engine.

Steam engines are constructed upon so many different principles, all claiming economy, that it is difficult to determine which is the best adapted for

paper mill purposes. The work being continuous, and the engine having to work day and night, an engine of the strongest possible construction is almost indispensable.

The beam condensing engine is the least likely to get out of order; its piston work being vertical, the wear on the cylinder is more equal, consequently less liability of passing steam, with friction in the cylinder reduced to a minimum. We will confine ourselves to the beam engine.

The power necessary to drive the machinery of a paper mill is very fluctuating, in consequence of the strength or weakness of the material operated upon: the lifting and lowering of the engine rolls, the condition of the roll bars and the bed-plate, have all to be considered. But 200 horse-power is ample for what is termed a one-machine mill; 150 horse-power being expended upon breaking and beating, and 50 horse-power for the paper machine and other necessary machinery connected with the manufacture.

It is also most important, where steam power is used, to keep the engine in a good state of repair, and carefully packed, thus preventing escape of steam. The engine ought to be frequently indicated, with a view to ascertain its working condition; this indicating is best done by a practical engineer, but the papermaker may himself periodically take a diagram for his own information.

We will endeavour to describe the theory and practice of indicating an engine with sufficient accuracy to give an idea of how the engine is working. The steam engine indicator is designed to show the pressure of steam in the cylinder at each point of the piston's stroke; this is indicated by a pencil moving up and down with the varying pressure of the steam, and at the same time having a

backward and a forward motion coinciding with that of the piston—a paper being placed upon the indicator drum, which, while the piston is advancing, is caused to make about half a revolution by means of a cord connected with a suitable part of the engine, and, while the piston is receding, is brought back to its first position. By the reaction of a spring, the pressure of the atmosphere being on the upper side of the piston, and when the communication with the cylinder of the engine is closed, it is on the under side, and if then the pencil be applied to the moving paper it will draw a line, which is called the atmospheric line. When the communication is opened between the under side of this piston and one end of the cylinder of the engine, the piston will be forced upwards by the pressure of the steam, or downwards by that of the atmosphere, as one or the other preponderates; and if now the pencil be applied to the paper on the moving drum, it will describe during one revolution a figure, each point in the outline of which will show, by its distance above or below the atmospheric line, the pressure in that end of the cylinder when the piston was at the corresponding point of its forward or return stroke. The diagram thus described shows the following particulars:—What proportion of the boiler pressure is obtained in the cylinder, how early in the stroke the highest pressure is reached, and at what pressure the steam is cut off. The indicator shows only the pressure at each point of the stroke; it tells nothing about the causes which have determined the form of figure it has described: the operator must conclude what these are by a process of reasoning and also by experience, and to be accurate in such is a high attainment.

A variety of diagrams will be given by the same engine under different circumstances; and it cer-

tainly is very instructive to the operator, as there is nothing more interesting than their careful study. With a knowledge of the circumstances under which each is taken, lines which at first appear meaningless become full of meaning,—that which before scarcely arrested the attention will now possess an absorbing interest. The operator becomes acquainted with an innumerable variety of forms, and learns the points and degrees, as well as the causes of their departure from the single perfect form; he becomes familiar with the effects produced by different movements of parts, and is competent to judge correctly as to the performance of the engine.

WOOD PULP.

This is a papermaking material which has not found much favour with the papermaker or the printer—the former complaining of its brittleness and the difficulty of retaining its surface for any length of time, the latter from the injury it does the printing plant. It may be suitable as an admixture with other materials for common cheap papers, but it certainly is not for fine papers; the staple material of the present time for fine papers being Spanish esparto and cotton and linen rags, and for printings and common writings esparto and straw.

RECEIPTS FOR HIGH-CLASS PAPERS.

In making papers of superior quality, considerable experience and skill are necessary in selecting and blending the material. The following receipts will produce papers, smooth, strong, tough, and possessing elasticity of feel and clearness of colour :—

EXTRA SUPERFINE CREAM.

FOR 300 LB. DRY PAPER.

S.P.F.F., ¼ ; Dark Fines, ¼ ;
Green Linen, ¼ ; New Pieces, ¼ ;
4 oz. ultramarine, marked B.B.A.C. ;
1½ gill cochineal ; 40 lb. pearl hardening.

SUPERFINE CREAM.

FOR 300 LB. DRY PAPER.

Dark Fines, ¼ ; S.P.F., ;
Superfines, ¼ ; Spanish Esparto, Fine, ¼ ;
6 oz. ultramarine, B.B.A.C. ;
1 gill cochineal ; 40 lb. pearl hardening ;
14 lb. dry starch.

FINE CREAMS.

FOR 300 LB. DRY PAPER.

Medium Spanish Esparto, ¼ ;
Fines, ¼ ; F.F., ½ ;
7 oz. ultramarine, marked B.B.R.V. ;
1½ gill cochineal.

EXTRA SUPERFINE COMMERCIAL POST.

Animal-Sized.

FOR 300 LB. DRY PAPER.

S.P.F.F.F., ½ ; Dark Fines, ¼ ;
New Pieces, ¼ ;
3 gallons engine size ; 5 lb. pure alum ;
5 oz. ultramarine, B.B.A.C. ;
1 pint cochineal ; ¼ oz. carmine ;
40 lb. pearl hardening.

SUPERFINE COMMERCIAL POST, Animal-Sized.

FOR 300 LB. DRY PAPER.

S.P.F.F., ½ ; Dark Fines, ¼ ; Supers, ¼ ;
3 gallons engine size ; 6 lb. pure alum ;
6 oz. ultramarine, B.B.A.C. ;
1½ gill cochineal ; 1 gill archil ;
14 lb. starch ; 40 lb. pearl hardening.

FINE CREAM COMMERCIAL POST, Animal-Sized.

FOR 300 LB. DRY PAPER.

F.F. Russian Rags, ½ ; Seconds, ¼ ;
No. 2 Spanish Esparto, ¼ ;
6 oz. ultramarine, B.B.R.V. ; 1 gill magenta ;
6 gallons size ; 10 lb. alum.

FOURTH CREAMS.

FOR 300 LB. DRY PAPER.

Second Fines, ¼ ; F.F., ¼ ;
No. 2 Spanish Esparto, ½ ;
6 pails size ; 30 lb. alum ;
9 oz. ultramarine, B.B.R.V. ; 2 gills archil.

FOURTH CREAMS.

FOR 300 LB. DRY PAPER.

Fine Oran Esparto, ½;
Tunis Esparto, ¼; F.F. Rags, ¼;
9 oz. ultramarine, B.B.R.V.;
2 gills magenta; 4 lb. dry starch.

SUPERIOR QUALITY OF DRAWING CARTRIDGE.

NO COLOURING MATTER.

Cartridge, ½; good Canvas, ¼; good Seconds, ¼.

EXTRA SUPERFINE POST PAPER.

FOR 300 LB. DRY PAPER.

Supers, ¼; Green Linen, ¼;
New Pieces, ¼; S.P.F.F.F., ¼;
3 oz. ultramarine, A.C.; 2 oz. carmine.
(The above is the highest class of post paper made.)

EXTRA SUPERFINE BLUE, High Colour.

FOR 300 LB. DRY PAPER.

S.P.F., ¼; Dark Fines, ¼;
Fine Spanish Esparto, ½;
9½ lb. ultramarine, B.B.R.V.;
½ lb. magenta lake.

CARD PAPER, SUPERFINE, Animal-Sized.

FOR 300 LB. DRY PAPER.

S.P.F., ½; Fines, ¼; Seconds, ¼;
3 oz. ultramarine, B.B.A.C.;
1 gill archil; 30 lb. pearl hardening.

DRAWING CARTRIDGE, SUPERFINE, Animal-Sized.

NO COLOURING MATTER, AND NO CLAY.

Cartridge, $\frac{1}{2}$; Sailcloth without seams, $\frac{1}{4}$; Seconds, $\frac{1}{4}$.
(This is a superior cartridge.)

DRAWING CARTRIDGE, SECOND QUALITY, Animal-Sized.

F.F., $\frac{1}{4}$; Thirds, $\frac{1}{4}$; No. 2 Spanish Esparto, $\frac{1}{2}$;
4 lb. starch; 20 lb. pearl hardening.

SUPERFINE CREAM ENVELOPE PAPER, Animal-Sized.

FOR 300 LB. DRY PAPER.

S.P.F., $\frac{1}{2}$; Seconds, $\frac{1}{4}$; New Pieces, $\frac{1}{4}$;
3 oz. ultramarine, B.B.A.C.;
$1\frac{1}{2}$ pint cochineal; 12 lb. starch.

SUPERFINE HIGH BLUE.

FOR 300 LB. DRY PAPER.

S.P.F. $\frac{1}{4}$; Medium Spanish Esparto, $\frac{1}{2}$;
Scotch Fines, $\frac{1}{4}$;
12 lb. ultramarine, marked A;
$\frac{3}{4}$ lb. magenta lake.

FINE HIGH BLUE.

FOR 300 LB. DRY PAPER.

F.F., $\frac{1}{2}$; Fine Oran Esparto, $\frac{1}{2}$;
8 lb. ultramarine, marked B.B.R.V.;
$\frac{1}{2}$ lb. magenta lake.

COLOURED PAPERS.

DEEP LILAC.

FOR 250 LB. DRY PAPER.

No. 3 Stuff; 5 pails size; 20 lb. alum;
30 oz. violet methyl, marked B.B.B.;
½ oz. eosine, marked A.

DEEP GREEN.

FOR 250 LB. DRY PAPER.

No. 3 Stuff; 5 pails size; 20 lb. alum;
22 lb. silk green paste, extra fine.
(This is a beautiful clear green.)

DEEP LILAC.

FOR 250 LB. DRY PAPER.

No. 4 Stuff; 20 lb. alum; 4 pails size;
8 oz. diamond fuchine; 3 oz. aniline blue;
50 lb. straw pulp.

No. 10—PALE GREEN.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, full bleached; 4 pails size; 20 lb. alum;
¾ lb. bichromate, ten minutes later;
2¼ lb. sugar of lead, ten minutes later;
15 oz. Paris blue, dissolved in hot water, adding half a gill of sulphuric acid.

No. 5—GREEN, Medium Deep Shade.

FOR 250 LB. DRY PAPER.

No. 4 Stuff; 60 lb. mechanical wood pulp; 5 pails size;
20 lb. alum; 2½ lb. bichromate, fifteen minutes later;
6 lb. sugar of lead, fifteen minutes later; 1½ lb. Paris blue.

No. 5—GREEN.

FOR 250 LB. DRY PAPER.

No. 4 Stuff; 60 lb. mechanical wood pulp;
2½ lb. bichromate, 15 minutes later;
6 lb. sugar of lead, 15 minutes later;
7 oz. Paris blue; 4 pails size; 15 lb. alum.

No. 12—PALE GREEN.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, full bleached; 60 lb. wood pulp;
3 oz. bichromate; 6 oz. sugar of lead;
4 pails size; 15 lb. alum; 3 lb. Paris blue.

No. 3—GREEN, Deep Clear Tint.

FOR 250 LB. DRY PAPER.

No. 3 Stuff; 1½ lb. bichromate;
3 lb. sugar of lead, fifteen minutes later;
2 lb. Paris blue, ten minutes later;
5 pails size; 20 lb. alum.

DEEP ORANGE.

FOR 250 LB. DRY PAPER.

No. 4 Stuff; 40 lb. wood pulp; 4 pails size;
20 lb. alum; 6 lb. bichromate; 18 lb. sugar of lead;
25 lb. Venetian red; 50 lb. straw pulp.

No. 9—SKIN COLOUR.

FOR 250 LB. DRY PAPER.

No. 4 Stuff; 60 lb. wood pulp; 4 pails size;
20 lb. alum; 9¼ lb. green copperas;
10½ lb. crystal soda; 8 oz. bichromate;
1½ lb. sugar of lead;

DEEP OLIVE.

FOR 250 LB. DRY PAPER.

No. 4 Stuff; 60 lb. wood pulp; 4 pails size;
15 lb. alum; 2 lb. green copperas;
2 lb. crystal soda; 2¼ lb. Venetian red.

No. 6—BUFF.

FOR 250 LB. DRY PAPER.

No. 4 Stuff; 60 lb. yellow wood;
4 pails size; 20 lb. alum; 13 lb. yellow ochre;
10 oz. Venetian red; 1 gill Brazil wood dye.

NANKEEN TISSUE.

FOR 200 LB. DRY PAPER.

Nos. 17 and 18 Rope Stuffs, ½; canvas, ½;
3 lb. potash; 3 lb. green copperas;
2 lb. crystal soda.

LILAC TISSUE, DEEP SHADE.

FOR 200 LB. DRY PAPER.

Nos. 17 and 18 Rope Stuffs, ½; No. 5 Stuff, ½;
8 oz. aniline blue; 3 oz. diamond fuchine;
2 oz. violet methyl, R.R.R.R. brand.

WHITE TISSUE.

FOR 200 LB. DRY PAPER.

Nos. 17 and 18 Rope Stuffs, ½; No. 5 Stuff, ½;
5 oz. ultramarine, B.B.A.C.; 2 gills Brazil wood dye.

BLUE TISSUE.

FOR 200 LB. DRY PAPER.

Rope Stuff, ½; good sailcloth, ½;
2 lb. ultramarine, B.B.A.C.; 5 gills Brazil wood dye.

FINE GREY WRITINGS.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, full bleached ; 6 pails size ;
25 lb. alum, 12 oz. bichromate, 2 lb. sugar of lead, to be dissolved together in one pail, and put into the engine while hot ;
3 oz. Paris blue, half-an-hour later ;
4 oz. logwood extract.

FINE GREY WRITINGS.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, full bleached ; 6 pails size ;
25 lb. alum ; 15 oz. bichromate ; 2½ lb. sugar of lead ;
6 oz. Paris blue, half-an-hour later ;
7 oz. logwood extract.

FINE GREY WRITINGS.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, full bleached ;
3 lb. ultramarine, B.B.R.V. ; 2 lb. Venetian red ;
4 lb. yellow ochre ; 6 pails size ; 20 lb. alum.

SUPERFINE GREY WRITINGS.

FOR 250 LB. DRY PAPER.

No 3 Stuff, full bleached ;
4 lb. ultramarine, B.B.A.C. ; 1 lb. bichromate ;
1½ lb. sugar of lead ; 3 lb. Venetian red ;
6 pails size ; 25 lb. alum.

[CATECHU BROWN WRAPPING.

FOR 250 LB. DRY PAPER.

Hemp bagging, ½ ; No. 4 Stuff, ½ ;
7 pails catechu ; 5 pails size ; 15 lb. alum ;
3 lb. bichromate.

CATECHU BROWN, Deep Colour.

FOR 150 LB. DRY PAPER.

No. 4 Stuff, unbleached; 3 pails size; 10 lb. alum; 3 pails catechu; 2 lb. green copperas; 3 lb. bichromate.

ANILINE BLUE, Deep Shade.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, full bleached; 5 pails size; 20 lb. alum; 4 oz. aniline blue; $\frac{1}{6}$ oz. diamond fuchine.

No. 13—ANILINE BLUE.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, full bleached; 5 pails size; 15 lb. alum; 3 oz. aniline blue; $\frac{1}{6}$ oz. diamond fuchine.

No. 70—ANILINE BLUE, Deep Colour.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, full bleached; 4 pails size; 15 lb. alum; 2 oz. aniline blue; $\frac{1}{6}$ oz. diamond fuchine; 6 oz. Berlin blue.

LILAC.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, full bleached; 5 pails size; 20 lb. alum; 3 oz. aniline blue; $\frac{1}{2}$ oz. diamond fuchine.

DEEP LILAC.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, full bleached; 5 pails size; 20 lb. alum; 4 oz. aniline blue; 1 oz. diamond fuchine.

No. 4—DEEP ANILINE BLUE.

FOR 250 LB. DRY PAPER.

No. 3 Stuff, full bleached ; 6 pails size ; 20 lb. alum ; $4\frac{1}{2}$ oz. aniline blue ; $\frac{1}{6}$ oz. diamond fuchine.

No. 7000—DEEP LILAC.

FOR 250 LB. DRY PAPER.

Nos. 3 and 4 Stuffs, half and half ; 4 pails size ;
15 lb. alum ; 2 oz. aniline blue ;
2 oz. diamond fuchine ; $3\frac{1}{2}$ oz. Paris blue.

No. 4—BERLIN BLUE.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, half bleached ; 5 pails size ;
20 lb. alum ; $\frac{1}{2}$ oz. fuchine ; 5 lb. Paris blue.

DEEP ANILINE BLUE.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, full bleached ; 5 pails size ;
20 lb. alum ; 9 lb. Paris blue ;
$3\frac{1}{2}$ oz. aniline blue ; 3 oz. diamond fuchine.

(The above blue presents a fine clear colour, very deep and uniform.)

No. 8—VENETIAN RED.

FOR 250 LB. DRY PAPER.

No. 3 Stuff, unbleached ; 50 lb. chemical wood pulp ;
4 pails size ; 15 lb. alum ; 60 lb. Venetian red ;
3 pints Brazil wood dye.

FINE YELLOW PRINTINGS.

FOR 200 LB. DRY PAPER.

Spanish Esparto, ½; Oran Esparto, ½;
2 lb. bichromate; 4 lb. sugar of lead;
3 pails size; 10 lb. alum.

No. 70—DEEP VENETIAN RED.

FOR 200 LB. DRY PAPER.

No. 4 Stuff, unbleached; 5 pails size;
20 lb. alum; 2½ lb. yellow ochre;
50 lb. Venetian red; 3 pints Brazil wood dye.

No. 58—PINK.

FOR 250 LB. DRY PAPER.

No. 4 Stuff; 5 pails size; 20 lb. alum;
3 oz. diamond fuchine, dissolved in 300 ounces of boiling water, and strained through a fine flannel or silk bag.

DEEP EOSINE PINK.

FOR 250 LB. DRY PAPER.

No. 3 Stuff; 5 pails size; 20 lb. alum;
12 oz. eosine, marked B.N., dissolved in boiling water, and strained through a flannel bag into the engine.

PALE EOSINE PINK.

FOR 250 LB. DRY PAPER.

No. 3 Stuff; 5 pails size; 20 lb. alum;
3 oz. eosine, marked B.N.;
½ oz. violet methyl—strain into the engine.

EOSINE A—DEEP PINK TO BLOOD RED.

FOR 250 LB. DRY PAPER.

No. 3 Stuff, full bleached;
13 oz. eosine, marked A; ½ oz. violet methyl.
(This is a deep pink of a beautiful shade.)

YELLOW WRAPPING, FOR POST PAPER.

FOR 250 LB. DRY PAPER.

No. 4 Stuff; 60 lb. mechanical wood pulp;
2 lb. bichromate of potash, fifteen minutes later;
4 lb. sugar of lead; 20 lb. alum; 4 pails size;
50 lb. straw pulp, by Lahosse's system.

YELLOW PRINTINGS.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, half bleached;
50 lb. mechanical wood pulp;
1¼ lb. bichromate, twenty minutes later;
¾ lb. sugar of lead, half-an-hour later;
15 lb. alum; 3 pails size; 50 lb. straw pulp.

No. 4—YELLOW.

FOR 250 LB. DRY PAPER.

No. 4 Stuff; 4 lb. bichromate, twenty minutes later
8 lb. sugar of lead, half-an-hour later;
20 lb. alum; 6 pails size; 40 lb. straw pulp.

No. 95—YELLOW.

FOR 250 LB. DRY PAPER.

No. 4 Stuff; 20 lb. mechanical wood pulp;
2¼ lb. bichromate, twenty minutes later;
7½ lb. sugar of lead, half-an-hour later;
20 lb. alum; 4 pails size.

No. 90—YELLOW.

FOR 250 LB. DRY PAPER.

No. 4 Stuff; 40 lb. mechanical wood pulp; 15 lb. alum; 4 pails size; 5 lb. bichromate; 8 lb. sugar of lead.

No. 29—YELLOW.

FOR 250 LB. DRY PAPER.

No. 4 Stuff; 15 lb. alum; 4 pails size; 1¼ lb. bichromate; 5 lb. sugar of lead.

No. 23—YELLOW.

FOR 250 LB. DRY PAPER.

No. 4 Stuff; 40 lb. mechanical wood pulp; 15 lb. alum; 4 pails size; 5 lb. bichromate; 11 lb. sugar of lead.

YELLOW PRINTINGS.

FOR 450 LB. DRY PAPER.

Tunis Esparto, ½; No. 2 Spanish Esparto, ½; 20 lb. French ochre; 4 lb. dark English ochre; 8 lb. sugar of lead; 4½ lb. bichromate; 2 lb. red chrome.

YELLOW PRINTINGS.

FOR 400 LB. DRY PAPER.

Tunis Esparto, ½; Oran Esparto, ½; 3½ lb. bichromate; 7 lb. sugar of lead.

CATECHU BROWN.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, unbleached; 4 pails size; 20 lb. alum; 12 pails catechu; 6 lb. bichromate; 3 lb. crystal soda.

CATECHU BROWN.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, half bleached ; 4 pails size ;
4 pails catechu ; 20 lb. alum ; 1½ lb. bichromate.

No. 134—CATECHU BROWN.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, full bleached ; 4½ lb. green copperas ;
4 pails size ; 3 pails catechu ; 20 lb. alum ;
3½ lb. bichromate.

No. 8—ORANGE.

FOR 200 LB. DRY PAPER.

No. 4 Stuff ; 50 lb. yellow mechanical wood pulp ;
20 lb. orange mineral ; 1½ lb. Venetian red ;
4 pails size ; 20 lb. alum.

(The orange and the Venetian red must be carefully strained through a fine wire or flannel bag.)

No. 68—ORANGE.

FOR 250 LB. DRY PAPER.

No. 4 Stuff ; 60 lb. mechanical wood pulp ;
15 lb. alum ; 4 pails size ; 30 lb. orange mineral.

No. 22—ORANGE.

FOR 250 LB. DRY PAPER.

No. 4 Stuff ; 60 lb. mechanical wood pulp ;
15 lb. alum ; 3 pails size ; 15 lb. orange mineral ;
1 lb. Venetian red.

No. 24—ORANGE.

FOR 250 LB. DRY PAPER.

No. 4 Stuff ; 50 lb. mechanical wood pulp ;
12 lb. orange mineral ; 15 lb. alum ; 4 pails size.

No. 95—ORANGE.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, only half-bleached or gas-bleached, and not potched ;
3 pails size ; 15 lb. alum ; 6 lb. bichromate ;
8 lb. sugar of lead ; 60 lb. superfine orauge.

No. 70—VENETIAN RED.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, half-bleached ; 2½ lb. yellow ochre ;
45 lb. Venetian red ; 20 lb. alum ; 5 pails size.

No. 125—ORANGE YELLOW.

FOR 250 LB. DRY PAPER.

No. 4 Stuff ; 40 lb. mechanical wood pulp ;
3 pails size ; 15 lb. alum ; 6 lb. bichromate ;
8 lb. sugar of lead ; 25 lb. Venetian red ;
50 lb. straw pulp.

No. 2—YELLOW WRAPPING.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, unbleached ;
50 lb. wood pulp, No. 2 quality ; 4 pails size ;
20 lb. alum ; 16½ lb. sugar of lead, brown ;
8 lb. bichromate ; 20 lb. Venetian red.

YELLOW OCHRE, FOR WRAPPING.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, unbleached ;
60 lb. wood pulp, No. 2 quality ; 4 pails size ;
15 lb. alum ; 20 lb. yellow ochre ;
5 oz. Venetian red ; 4 oz. magenta lake.

PALE ORANGE.

FOR 250 LB. DRY PAPER.

No. 4 Stuff; 40 lb. wood pulp; 4 pails size.
15 lb. alum; 15 lb. superfine orange.

No. 115—GREY.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, half-bleached; 4 pails size;
20 lb. alum; 3 lb. green copperas;
3 lb. crystal soda; 4 lb. yellow ochre, dark;
4 lb. yellow ochre, light; 5 oz. Venetian red.

No. 34—VENETIAN RED.

FOR 250 LB. DRY PAPER.

No. 4 Stuff; 40 lb. yellow wood pulp;
4 pails size; 15 lb. alum; 48 lb. yellow ochre;
50 lb. Venetian red.

(This is a beautiful deep Venetian red, principally used for the covers of serials.)

No. 84—FAWN.

FOR 250 LB. DRY PAPER.

No. 4 Stuff; 4 pails size; 20 lb. alum;
2 lb. green copperas; 2 lb. crystal soda;
1½ lb. Venetian red.

No. 2—FAWN.

FOR 250 LB. DRY PAPER.

No. 4 Stuff; 20 lb. chemical wood pulp;
5 oz. ultramarine; 1 lb. Venetian red;
4 lb. yellow ochre, French.

No. 40—DEEP PARIS BLUE.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, half bleached ; 4 pails size ;
20 lb. alum ; 2 lb. logwood extract ;
6 lb. Berlin or Paris blue ; 2 pints cochineal.

SATURNINE RED.

FOR 250 LB. DRY PAPER.

No. 3 Stuff ; 4 pails size ; 20 lb. alum ;
50 lb. saturnine red ; 5 lb. superfine orange.

CHROME ORANGE.

FOR 300 LB. DRY PAPER.

No. 1 Stuff, full bleached ; 25 lb. alum ;
6 pails size ; 56 lb. chrome orange paste, No. 1.

(This is a fine clear orange for a good quality of paper.)

SOLUBLE BROWN.

FOR 250 LB. DRY PAPER.

No. 4 Stuff, half bleached ; 5 pails size ;
20 lb. alum ; 15 lb. soluble brown.

(This colouring matter must be carefully strained into the engine. It is the best substitute for catechu dyed papers, and has all the characteristics of catechu, and also the advantage of being much cheaper.)

VIOLET, Deep Shade.

FOR 250 LB. DRY PAPER.

No. 3 Stuff, full bleached ; 25 lb. alum ;
5 pails size ; 6 lb. violet methyl, marked R.R.R.R.
3 oz. blue methyl.

COLOURED ESPARTO PAPERS.

DARK YELLOW.

FOR 400 LB. DRY PAPER.

14 lb. bichromate of potash;
1¾ lb. brown sugar of lead, dissolved in one pail of hot water—strain into the engine through a flannel bag;
2½ lb. green copperas, one hour later; 25 lb. alum.

ORANGE YELLOW.

FOR 400 LB. DRY PAPER.

Oran Esparto; 7½ lb. bichromate;
15 lb. brown sugar of lead, dissolved in 5 pails of hot water—strain through a flannel bag;
¼ lb. Venetian red; 25 lb. alum; 7 pails size.

FINE DEEP BLUE.

FOR 400 LB. DRY PAPER.

Oran Esparto; 1 lb. crystal soda;
10 lb. prussiate of potash;
3 lb. green copperas, dissolved in 4 pails of hot water;
4 quarts iron liquor;
1 oz. magenta, dissolved in one pail of hot water;
25 lb. alum.

CHOCOLATE BROWN.

FOR 400 LB. DRY PAPER.

400 lb. Oran Esparto; 37 lb. Venetian red;
3 lb. catechu; 5 lb. bluestone; 5 lb. green copperas;
4 lb. ultramarine—all one hour apart;
20 lb. alum; 7 pails size.

FINE ROSE TINT.

FOR 400 LB. DRY PAPER.

Medium Spanish Esparto, ½ ; good Oran Esparto, ½ ;
2 oz. eosine, marked A, dissolved in one pail of boiling water, and strained through a flannel bag.

ROSE TINT.

FOR 400 LB. DRY PAPER.

400 lb. Oran Esparto ; 14 lb. Venetian red ;
1 lb. chrome yellow ; 20 lb. alum.

STRAW TINT.

FOR 400 LB. DRY PAPER.

400 lb. Oran Esparto ; 1½ lb. bichromate of potash ;
3 lb. white sugar of lead, dissolved in one pail of hot water ;
¼ lb. ultramarine ; 1½ pint iron liquor.

AMBER.

FOR 400 LB. DRY PAPER.

400 lb. Oran Esparto ;
½ lb. chrome yellow, mixed in the engine one hour ;
1 pint iron liquor ; 20 lb. alum ; 6 pails size.

LIGHT BUFF.

FOR 400 LB. DRY PAPER.

400 lb. Oran Esparto ; 4 lb. green copperas ;
4 oz. sugar of lead ; 3 lb. bichromate of potash ;
15 lb. alum ; 5 pails size ;

ORANGE BUFF.

FOR 400 LB. DRY PAPER.

400 lb. Oran Esparto ; 6 lb. bichromate of potash ;
8 lb. sugar of lead ; 14 lb. Venetian red ;
20 lb. alum ; 6 pails size.

FINE AMBER WRITINGS.

FOR 300 LB. DRY PAPER.

Medium Spanish Esparto, ½ ; F.F. Rags, ¼ ; Thirds, ¼ ;
6½ oz. nitrate of lead ; 3 oz. bichromate of potash ;
11 oz. Venetian red, strained through a silk bag ;
30 lb. alum ; 8 pails size.

DETAILS OF PREPARATION OF THE SEVERAL SORTS OF COLOURING MATTER PREVIOUSLY MENTIONED.

CATECHU.

Boil in an iron boiler 25 pails of water, then add 200 lb. of finely-powdered catechu gradually, and keep stirring. Boil until thoroughly dissolved, which will occupy from two and a half to three hours of brisk boiling. Put it into casks, and let it remain until cold. While the catechu is cooling, dissolve 12 lb. of bluestone; let it also remain until cold. When both are perfectly cold, add the bluestone to the catechu, and stir well.

Care must be taken not to add either in a hot state, as by doing so the colour will be injured.

BERLIN BLUE.

Dissolve 100 lb. of yellow prussiate of potash in one boiler; dissolve 100 lb. of green copperas in

another boiler. When both are properly dissolved, let them be put together in a boiler with a close-fitting cover; then dissolve 20 lb. of bichromate of potash, and add it to the prussiate and the copperas. Boil again, and keep stirring; then add 17 lb. of vitriol, stir thoroughly, and let it remain for two or three days. Prepare some casks in the interval for the reception of the solution, by boring holes in the staves—say 6 in number—one above the other, and 6 inches apart, beginning with the bottom one, which must be 2 feet from the extreme bottom. Into these holes fit long plugs, which can be easily removed. When the casks are ready, fill up with the prepared solution, and allow them to stand undisturbed until properly settled; then run off the water by the holes in the staves, removing the plugs one by one—beginning with the top one—as the cask gets empty, until the blue makes its appearance, when the plugs should be replaced, and the casks again filled up with water and well stirred; this washing to be continued four or five times, as circumstances permit. The oftener it is washed, the brighter the blue will be.

PERNAMBUCO DYE-WOOD.

Put into a boiler 20 pails of water, and bring it to the boiling point; add 200 lb. of Pernambuco wood, and boil for eight hours. Put it into casks, and wash same as for Berlin blue, adding 8 lb. of the muriate of tin.

ANTICHLORINE: ITS MANUFACTURE.

Procure a large cask—or, better, have one made without the bulge which ordinary casks have in the

centre; raise it upon a stand 3 feet high; fit into it two frames or screens, which can be easily removed when desired; work across this frame a network of white cord or twine of sufficient strength to support a weight of 200 lbs., and have it sufficiently close to prevent the soda falling through the meshes. Upon each of these screens put 200 lb. of the ordinary crystal soda of commerce, then put on the lid or cover, and clay it round perfectly tight. Make two or three small air holes in the clay, or have an air-cock attached to the cover underneath the screens, and attached to the cask a pipe connected to a retort, into which put 9 lb. of sulphur. Start a fire below the retort, and, when the sulphur begins to melt, heat a piece of iron rod to a red heat, and insert it into the sulphur, which will commence to burn and send its fumes through this pipe into the cask, passing through the crystal soda, converting it into antichlorine. When this 9 lb. of sulphur is all consumed, the operation must be repeated, using again 9 lb. of sulphur.

Proportions:—400 lb. of crystal soda and 18 lb. of sulphur.

Dissolve the antichlorine in the cask, and bottle it off into carboys, and convey it to the beating engine department.

BLEACH TEST.

Mix $\frac{1}{4}$ oz. of starch into a paste with cold water, then add boiling water until it amounts to one pint, adding two drachms of iodide of potassium; when cold it is ready for use. Drop a few drops upon a handful of stuff: if any chlorine is present, it will immediately turn black; if none, it will remain unchanged.

COCHINEAL: ITS PREPARATION.

Put 3 lb. of cochineal flies into a carboy; pour in ammonia until they are thoroughly saturated; let it stand closely corked for ten days; but if they get dry during that time, add more ammonia, then at the end of ten days pour the contents of the carboy into a flannel bag. Put it into a vessel three parts filled with water, and let it remain for 24 hours; then strain and squeeze the bag until the colour is all extracted. 3 lb. of flies ought to make 6 gallons of colouring, to suit the papers previously mentioned.

ENGINE SIZE—FRENCH METHOD.

This size, if properly made, ought to be as white as milk, and should not alter the colour of the stuff in the slightest degree. Boil 13 pails of water in a copper-shelled boiler. Introduce 90 lb. of crystal soda, keep boiling for half an hour, then add gradually 200 lb. of finely-powdered rosin, and keep stirring; boil for two hours after all the rosin is added, then add 5 pails of cold water, and boil again for an hour and a half; then put it into stock-chests, and allow to remain for ten days, or longer if possible. The best method is to have a number of stock-chests, each capable of containing a week's size, using out of the one while you are filling up the others.

Cubic contents of small rosin boiler, 38,714 cubic inches.

PREPARATION OF SIZE FOR THE ENGINES.

Put into a large copper-shelled boiler, three-fourths filled with water, 20 pails of this prepared rosin. Raise the heat to 40°, and add 120 lb. of potato flour, previously mixed with cold water to the con-

sistency of cream. Raise the heat up to 60°, then put in such a quantity of water so that there will be of rosin 4 lb., starch $3\frac{1}{3}$ lb., and of soda 2 lb. in every 4 pails of the prepared size. In all, the boiler will contain 144 pails of size.

Cubic contents of large-size mixer, 153,400 cubic inches =about 202 pails, the pail being 756 cubic inches.

TURPENTINE SIZE.

FOR AN ENGINE OF 300 LB. DRY PAPER.

1 lb. potash ; $6\frac{3}{4}$ lb. turpentine ; $6\frac{3}{4}$ lb. starch ; $6\frac{3}{4}$ lb. water. Boil slowly, and keep stirring for two hours ; it is then ready for the engine.

SOAP SIZE,

MADE AND USED IN THE INTERIOR OF RUSSIA.

200 lb. tallow ; 35 lb. potash, dissolved in 15 pails of water, adding 14 lb. lime.

Melt the tallow first, then add the potash water, one pailful at a time, until the grease is completely killed. Keep continually stirring, and be careful not to allow the size to spill while stirring, as it is very likely to do.

The best proportions are as follows :—

7 lb. tallow ; 2 lb. potash ; 1 lb. lime ; 6 gallons water. Boil 6 hours. Use 2 gallons to the engine of 250 lb. dry paper.

ANILINE COLOURS.

It is very important to the papermaker to have some knowledge of Aniline Colours, as they enter largely into the production of tinted papers.

The best method of preparing them is to dissolve

them in wooden tubs, as follows:—Weigh off the required quantities, put them into the tub, pour on boiling water, and stir well. The proper proportion is one part of colour to 100 parts of water, which ensures a perfectly dissolved colouring matter. The solution should be prepared at least 24 hours before using, which assists the decomposition of the colour. Aniline Colours should be carefully filtered through a fine flannel bag,—or, better, through a white silk bag, which ensures a perfectly clean colour, and prevents specks on the paper.

The following is a list of the Aniline Colours most suitable for dyeing paper pulp, detailing their effect when used alone, or combined with other colouring agents.

RED LAKE.

A fluid fast in colour, which produces a beautiful pink for extra superfine, superfine, note, and tissue papers; also well adapted, in combination with the best brands of ultramarine, for producing that warm cream colour (of a bright and clear appearance) so much desired in high-class cream wove and laid post.

This colour holds a prominent position for its great strength and durability combined with cheapness.

EOSINE

Is a comparatively new colour, much used by makers of tinted papers on the Continent. It produces the finest shades of pink down to a deep yellowish red, and, combined with sugar of lead, produces a bluish pink on tissue—a deep and clear colour approaching to blood red.

LAC À LA COCHENILLE

Is a colouring matter, distinguished for its fine shade, and, on account of its cheapness, is well adapted for red and pink papers of a medium quality, such as posters, wrapping, and blotting papers.

DIAMOND MAGENTA

Is used for producing common reds, toning up news, and, in combination with aniline blue, for producing aniline blue papers and aniline lilacs.

VIOLET METHYL

Produces the brightest violet shades, also brightens up white papers, and, in combination with Paris blue, makes that deep blue which is so attractive to the eye, owing to its bright and handsome appearance.

PARIS BLUE

Is a colouring matter which requires care and experience in preparing for the engine, for it is often sold in an impure state. Papermakers ought to see to its purity before using, as it is often considerably adulterated with starch, farina, clay, and other foreign matters, which are added to make weight, and are of no use to the papermaker.

The best brands are No. 1 and No. 5: they are of great yielding power for light and dark blue tissues and for ordinary papers.

Paris blue is sometimes sold in paste: when sold in this form, it never contains more than 40 per cent. of colouring matter. It is also supplied in pieces, which are easily soluble in water, and is very suit-

able for deep blue papers. The brands No. 6 and No. 7 produce very dark shades of blue by adding violet methyl. When consistent with the paper to be produced, a little dilute sulphuric acid should be added to the pieces, as it assists their yielding power, and brightens the colour considerably.

METHYL BLUE

Is a very brilliant colour, not affected by chlorine. It is much used in white papers, and for making fine shades of blue; it also combines readily with magenta for the production of lilacs.

SILK GREEN

Is a chemically pure colouring matter, producing beautiful shades of green; it can be easily tinted by the use of Paris blue or chrome yellow.

METHYL GREEN.

Used for very fine shades of green of a bluish tinge; when used with methyl blue, it produces all the shades of peacock green, giving a most beautiful effect.

ULTRAMARINE.

Ultramarine is used most extensively by paper-makers, not only to brighten, but actually to colour paper stuff. In common papers, such as news and printings, this colour is added to increase the liveliness of the paper, and give it a good bright whiteness. Ultramarine, however, is used also in blue

papers of medium quality, and, when carefully made and of the finest quality, can be used for the best papers.

The two defects which act against the use of ultramarine in papermaking are the grit or small particles of hard foreign substances, and the inability of the blue to stand the alum used in sizing. With these disadvantages removed, pure ultramarines might be used for fine papers. Papermakers should always examine their blues; and this can be done very simply.

Weigh about 50 grains of each sample of ultramarine, and mix each well with 100 grains of terra alba, and look at the mixtures side by side in a good light. The eye can get a good estimate of colour from this test; but, to make more certain, examine the samples over again, only letting the price of each sample guide the weight in grains to be tested, and proceed in the usual way. Thus, supposing four samples at 65/, 72/, 76/, and 80/ respectively are to be tested, proceed as follows:—Bring each sample to a level so far as price per cwt. is concerned. The 65/ sample being 15/ cheaper than the 80/, more of it can be bought for 80/; so the test must be carried out accordingly. If 80/ equal 112 lb., 65/ will give you 138 lb. The sum in each case is—

65	:	80	: :	112	:	138
72	:	80	: :	112	:	124
76	:	80	: :	112	:	118

By mixing these relative proportions of ultramarine, each with 100 grains of terra alba, upon white paper, the eye will discern the best sample for the money. In the case of the 80/ blue, of course use 112 grains.

To test its alum-resisting properties, dissolve the

same amount of each sample in water, and mix in this water about $\frac{1}{2}$ lb. of pulp. When thoroughly mixed, and each lot of pulp is well and evenly coloured, add one glassful of the ordinary mill alum liquor, either from pure alum or aluminous cake, to each, losing no time over the operation. Stir each well and continually with a glass rod, and note the glasses carefully as to the length of time each sample keeps its colour.

The above tests are excellent ones, and practically a safeguard to any papermaker in buying ultramarines.

SCRAPS OF CHEMISTRY

Connected with the Manufacture of Paper.

In these days of progress it is absolutely necessary for the papermaker to have some knowledge of chemistry. It solves for him many problems, and points out the cause of many difficulties with which he has to contend, and their various remedies.

ALUM.

The alum of commerce forms an important item in the manufacture of paper. Impure alum should at all times be rejected, especially if iron be present in it. Considerable difficulty is often experienced by the papermaker in producing a uniform colour throughout a given quantity of paper; variations occur, which, if properly investigated, will in many cases be found attributable to the alum. Alum intended for the beating engine should be perfectly pure, and ought to be weighed with accuracy, and

dissolved in a known quantity of water. This ought to be tested at frequent intervals as to its strength, which ought to be kept as uniform as possible. A good system of ensuring a uniform supply of alum to the engine is to fix a tabular statement in a convenient situation, so that the beaterman can command a view of it at all times. For example: the beaterman is ordered to put in a given quantity of alum at 5°; by condensation of steam it only stands 4°: the table should acquaint him at a glance how much additional alum he is to use. All he requires to do is to test the alum for every engine he furnishes, which occupies very little time, and repays him a hundredfold in the saving of trouble in striking the colour. This will be best exemplified in the manufacture of blue papers. The slightest variation in the alum varies the colour: hence arises the necessity of great care, in order to produce the desired shade.

When alum contains iron in any considerable quantity, it should be rejected. The simplest method of testing its purity in that respect is to dissolve a small quantity in distilled water, and add by degrees a few drops of pure carbonate of soda to neutralize any free acid; next add a few drops of a solution of yellow prussiate. If any iron be present, it will assume a blue colour upon the addition of the yellow prussiate solution. The intensity of the blue will indicate the quantity of iron present. Alum should be periodically tested in this manner.

ALUMINOUS CAKES.

In many paper mills where low-classed printings and news are made, aluminous cakes are used instead of alum. Aluminous cakes are made from

china clay, which is treated with strong sulphuric acid in suitable vessels. The acid has the effect of rendering the alumina soluble by dispelling the silicic acid and forming soluble sulphate of alumina. Hence aluminous cakes are valued according to their percentage of soluble alumina. The examination of aluminous cakes must be undertaken by a properly qualified analyst. A great fault in these cakes is the presence of free acid, and sometimes dirt, in abundance. Both these deleterious agents ought to receive the careful attention of papermakers.

BLEACHING POWDER.

This is a very important chemical, and one which enters largely into the cost of working a paper factory; hence the necessity of the manager being in a position to know whether the article with which his employer is supplied is of the proper quality or not, as its value to him depends entirely upon the amount of chlorine it contains.

To test bleaching powder as to the percentage of chlorine contained therein, proceed as follows :—

Take 100 grains of arsenious acid; dissolve them in four fluid ounces of hydrochloric acid, which possibly will require a little heat; the solution is then diluted with 6 ounces by measure of distilled water. The whole ought to measure exactly 10 ounces; consequently each ounce will contain 10 grains of arsenious acid.

Take 100 grains of bleaching powder from various parts of the sample to be tested; rub it in a mortar with a little water, then add as much water as will twice fill an ordinary graduated alkalimeter; allow the coarse grains to settle, then fill the alkalimeter, which is divided into 100 parts. Each part will con-

tain half a grain of bleaching powder. Take one ounce of the arsenious solution, and add to it a little sulphate of indigo, sufficient to render it of a distinct blue colour; then into this pour slowly the bleaching liquor from the alkalimeter until the blue colour disappears, stirring continually during the operation. Note the number of graduations required to effect this change.

Every 10 grains of the arsenious acid is equal to 7·2 grains of chlorine, so the quantity of bleaching liquor taken to decolour the indigo will contain that amount of chlorine. Suppose it has required 48 graduations of the bleaching liquor to effect the change, this will be equal to 24 grains of bleaching powder: therefore 24 grains of bleaching powder will contain 7·2 of chlorine; and if 24 contain 7·2, 100 will contain 30. The sample will therefore contain 30 per cent. of chlorine.

EXAMINATION OF SODA AS TO ITS CAUSTICITY.

The value of soda to the papermaker depends upon the amount of caustic alkali which it contains. The admixed salts contained in soda consist of various sorts, and are of no value to the papermaker. As the proportion of these salts varies very much, it is necessary to examine the soda periodically, to ascertain the quantity of caustic alkali it contains.

This can be done very easily, and by a re-agent which is applicable to both caustic soda and soda ash. Caustic soda differs from soda ash in that its alkali (pure soda) is in a free and uncombined state, whilst the alkali of soda ash is united to an acid—carbonic acid. This acid, however, is but a weak body, and the test, which serves to ally with the caustic alkali in caustic soda, is of sufficient strength

to perform a similar function in the case of soda ash, by expelling the carbonic acid in the form of a gas. To effect this thoroughly, it is necessary to boil the solution of soda ash during the entire operation, in order that the carbonic acid gas should not dissolve in the water or solution of soda ash.

One equivalent of soda, represented by the figure 31, is exactly neutralized by one equivalent of acid, 40. The absolutely correct system of preparing the test re-agent above alluded to would be too technical an operation except for a properly qualified analyst. The following test, however, can be simply prepared :—Add to half-a-gallon of distilled water about 3 or 4 ounces (fluid) of pure sulphuric acid, and allow the mixture to get cool; fill a "Winchester quart" bottle with this test acid, keeping the stopper close, and putting the acid in a place where the temperature is even and not liable to rise above 60°; next weigh out carefully 25 grains of pure anhydrous carbonate of soda, and dissolve them in about one half an evaporating basinful of distilled water. The basin can hold, say about one pint. Set this over a spirit lamp or Bunsen burner to boil, having a good long glass rod in the basin, and having also added 5 or 6 drops of litmus. Meanwhile fill an alkalimeter with your test acid. (Mohr's alkalimeter and clip, fitted also with a float, are the best things to use, and can be had of any chemical-instrument maker.) The alkalimeter will contain 1000 grains of the test acid. When the solution of pure soda is boiling, add the acid cautiously, for fear of the effervescence causing overflow and loss. Add gradually until the litmus shows signs of reddening. Allow the solution to boil briskly now, and add the acid drop by drop until the litmus is of a purple tint. Note now whether this purple tint is stable after boiling, and if so, dot down the number of

grains on the alkalimeter corresponding with the float-line; then add one or two drops more acid until the soda solution turns a permanent red, and dot down this number also.

Now, supposing the test acid denotes 800 as the first figure, and 810 as the figure when the soda turned red: take the mean, 805. Then 25 grains of pure carbonate of soda are equivalent to 805 grains of acid liquor, and of course *vice versâ.* The following calculation will give the strength of the test liquor:—

Carb. Soda.		Pure Soda.		Carb. Soda.		Pure Soda.
53	:	31	: :	25	:	14·56

Therefore 805 grains of the test acid are equivalent to 14·56 of pure alkali. This experiment must be made three times to prove the accuracy of the test liquor, as everything depends upon the latter being perfectly true, seeing that it has to do duty in every future case of testing.

Having found the above correct, the "Winchester" is duly labelled, and 25 grains of each sample of soda ash are taken and boiled, and tested exactly in the same manner. Suppose a sample of 25 grains requires 705 grains of test acid, the following is the calculation:—

Test Acid.		Alkali.		Test Acid.		Alkali.
805	:	14·56	: :	705	:	12·75

then $12·75 \times 4 = 51\%$ alkali (say).

This test is very accurate, provided the test acid is not too strong, and is added cautiously so as not to produce violent effervescence.

In examining caustic soda the above test acid is used, but the sample of caustic is dissolved in cold water, and then examined in the same way. It is, however, better to take a piece of caustic and weigh

it at once, and not endeavour to obtain any exact weight. Caustic is so deliquescent, that before it is possible to weigh out any exact given weight, the soda would probably absorb a large amount of water from the air. Weigh a piece about the size of a filbert, and, when the result is obtained, the following calculation will give the exact percentage :—

Weight		Amount of				Percentage of
of	:	alkali	: :	100	:	alkali
sample		absorbed				in sample.

RULES TO BE OBSERVED IN THE EXAMINATION OF SODA.

The vessels and glasses must always be clean.

The water used must be distilled.

The operator must take great care to read correctly the volume of the test acid used. Nothing facilitates this so well as a Mohr's float.

The tincture of solution of litmus must be kept in a well-stoppered narrow-necked bottle, and frequently in a dark cupboard. No alkali must be added to it on any account, as it will corrupt the result. Should the solution decompose or turn brown, one drop of weak ammonia may be added, but it is better to make some fresh solution.

COLOURED TEST PAPERS.

The most efficient test papers are litmus and turmeric ; they surpass liquid tests in delicacy and general application.

LITMUS TEST PAPER.

To prepare litmus paper, rub good litmus with a little hot water in a mortar, and pour the mixture

into an evaporating basin; add water until the proportion is half-a-pint of water to one ounce of litmus; cover up so as to keep warm for an hour, after which the liquid must be filtered, and fresh hot water poured on the residue. This is to be boiled, covered up as before, and allowed to stand. The operation is to be repeated a second time, and, if much colour comes, a third time.

The first solution is to be kept separate from the second and third, which may be mixed together. The first solution will not require evaporation, but the others may be so far reduced in quantity, that when a piece of blotting or filtering paper is dipped into them and dried, they will impart to it a blue colour of sufficient intensity for use.

The paper is then to be dipped in the solution. The paper—blotting will suit very well—should always be unsized, of good colour, and moderate thickness, say from 15 to 20 lb. demy, and cut into pieces of a convenient size for dipping. Particular care should be taken to use paper as free as possible from earthy matter, and especially from carbonate of lime. Sized papers produce a finer tint on the surface, but are not so delicate as a test.

Pour the litmus solution into a plate, and draw the slips of paper through it in such a manner that the fluid will come in contact with both sides; allow the solution to drip, then hang the slips across two thread lines to dry.

The tint ought to be a distinct blue, and may be tested as to its delicacy by touching the paper with a very dilute acid, observing whether the red colour produced is vivid or not. It should, when dry, be tied up into bundles, and preserved from the air and light. A wide-necked glass-stoppered bottle is best suited for this purpose. Put in the test papers, and paste round the sides of the bottle a piece of

dark paper to exclude the light, as both air and light tend to destroy the colour and efficacy of the test paper.

TURMERIC TEST PAPER.

This paper is prepared in a manner similar to litmus paper. A hot infusion of finely-crushed turmeric can be made by boiling one ounce of turmeric in 12 ounces of water for half-an-hour; strain through a fine cloth or silk bag, and leave the fluid to settle for a few minutes. The liquid should be of such strength that paper dipped into it and then dried should be of a fine yellow colour. The paper should be of the same quality in every respect as for litmus paper. No particular care is necessary in drying, as with litmus paper; but both papers should be prepared where acid and alkaline fumes cannot come in contact with them, as they injure the colour of both.

USE OF THE TEST PAPERS. X

In using the test papers with a fluid suspected to contain free acid or alkali, or to find if one of them predominates, all that is necessary is to moisten them with the liquid and observe the change. If the fluid be acid, the blue colour of the litmus paper will change immediately to red; if alkaline, the yellow colour of the turmeric paper will change to brown. The moistening may be effected by dipping a glass rod into the liquid to be tested, and then touching the test paper.

These tests must be made by daylight, if a minute estimate of the change is necessary, as artificial light will not enable you to note the delicacy of the action of acid or alkali when a small portion is present.

BLOTTING PAPER.

This is a paper which, to bring it to a high standard of perfection, requires a greater amount of care and experience in its manufacture than is generally supposed. Every one who uses the article knows that its value consists in its absorbing qualities, and that depends as much in the mode of preparation as in the material from which it is made.

In selecting materials for blotting of a high class, cotton rags of the weakest and tenderest description procurable should be chosen. Boil them with 4 lb. of caustic soda to the cwt.—that is, if you have no facilities for boiling them with lime alone.

When furnished in the breaking engine, wash the rags thoroughly before letting down the roll; when this is done, reduce them to half-stuff, and as soon as possible empty into the potcher, or convey to the potcher as the case may be, and bleach with great care. When up to the desired colour, empty into the drainer, and drain immediately. It may be mentioned that the breaker-plate ought to be sharp when starting to blottings.

The beater roll and plate should also be in good order, and the stuff beaten off smartly, not to exceed one hour and a half in the engine. For pink blottings furnish two thirds of white cottons and one third of turkey reds if they can be got; if not, dye with cochineal to the desired shade, empty down to the machine before starting, and see that the vacuum pumps are in good condition. Remove the weights from the couch roll, and, if there are lifting screws, raise the top couch roll a little. Now take the shake belt off, as the shake will not be required. Press light with the first press, and have the top roll

of the second press covered with an ordinary jacket similar to a couch roll jacket. Dry hard, and pass through one calender with the weights off, and the roll as light as possible,—just enough to smooth slightly. In this way the author has made blotting which was considered a good article.

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One cubic sachen* of the wood of the aspen (which had been in the mill yard exposed to the sun for 12 weeks), weighing 9340 lb., produced 5384 lb. dry pulp fit for manufacturing into paper, and 70 lb. waste unfit for paper.

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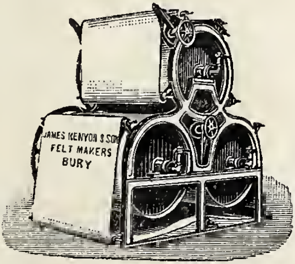

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